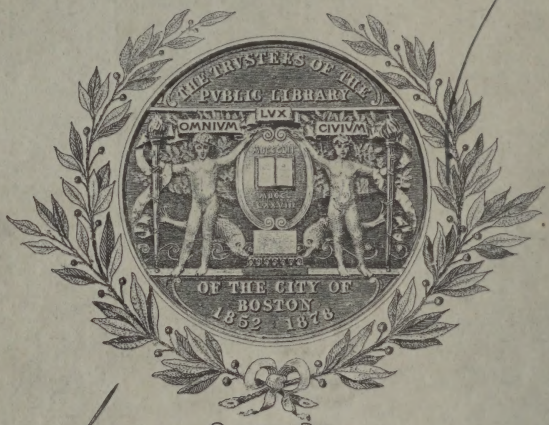

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THE VOICE

A SCIENTIFIC STUDY OF ITS FORMATION AND EMISSION AND ITS AILMENTS

BY

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Dr J. BARATOUX

1925

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1925

INTRODUCTION.

When, at the beginning of my medical career, I gave myself up to the task of studying thoroughly the question of the tuition of the art of singing, I was surprised to hear professional people speak to me a language I could not understand. I then read treatises on the voice to try and find a satisfactory explanation, and I was obliged to come to the conclusion, that each teacher had a method of his own founded purely on empiricism, which is after all a transitory form of ignorance.

The singing-master has one great excuse : he has not had at his disposal the necessary means of learning his trade. There is no school were one can get the proper training to be able to exercise the profession of a teacher. This is the only branch of higher education where the masters are chosen by a committee which utterly lacks competence : how many artists do we find on the higher board of the Academy of Music?

No one can, without certificate, open an elementary school, but one can become a singing-master by the simple means of putting up a plate on one's door, or an advertisement in a theatrical paper.

Some time ago, an artistic association was founded for the purpose of making regulations as regards the tuition of the art of singing. To be a member, it is compulsory to have been on a lyrical stage, and hold there a leading part for, at least, fifteen years; but is this the only condition for the making of an efficient teacher?

We had thought that this Society would have tried to raise the level of vocal education, by summoning the help of various scholars acquainted with every question concerning singing, and founded a school where anatomy, physiology of the vocal organs, history of art and music would have been taught together with natural philosophy, phonetics, etc., as all these sciences are part of the attainments which the singing-master must possess to really deserve that title. But we have been quickly disappointed. If one takes the pain of reading some of the articles, which deal with the way vocal education is managed, one will easily see that the singer wishes to shut himself up against all intruders who had hoped to put this knowledge at his service.

The author of these articles writes : « the singing-master has a dozen pieces of advice to give his pupils : how to breathe naturally, how to give the vocal chords their normal tension, how to dispose properly mouth, nose and all other sonorous cavities. One can imagine how the experience acquired by the singing-master in his previous profession as a singer, will be far more effectual to him, as regards these physiological appropriations, than the *speculum* of a laryngoscope ». The only answer to make to this, is to repeat what this critic has himself written on the subject of the competitive examinations of the French Academy of music, « Le Conservatoire », this great destroyer of voices, where reigns chiefly incoherency in the matter of teaching.

Another critic appeals in his paper to all these whose knowledge can be useful or interesting to the singer who, sprung from the people or the soil, has had neither time nor possibility to cultivate and improve his mind. He adds : « How can the singer learn even the matters concerning his art if, as we have shown, nobody cares to speak or write for his benefit? » A little further the same author writes : « We wish these very useful scholars (the laryngologues) to continue their labours and studies in the silence of their laboratories, and attend upon us as best they can : their task is beautiful and difficult enough without their adding to it the precarious one of singing-master! »

Further still, another author brings us back to the old times of alchimy. He writes : « The physiologist may know more thoroughly the organs which go to produce phonation; but he is too rigid in his conclusions, too disdainful of psychic side questions, to understand their inmost working, mysterious and as if it was scattered, which the artist, with his refined sense of divination, can more surely pervade. » It seems that one could easily adapt to this writer the following judicious remark which Mayan made one day : « I have just lived and that is all, as long as my teaching was clear and plain, I only made money the day my pupils could no more understand what I said. »

There are not two kinds of physiology to explain the mechanism of the vocal organ, physiology doesn't change according to the different doctors or singers, and is not more mysterious for the one than for the other. It is to explain it that we have decided to publish this work, written a long time ago and often altered since, hoping that it may be useful as well to the practitioner as to the artist.

N. B. — In the English translation which is presented herewith, it must not be forgetten that the pronunciation of the vowels has been left, as it is made in the French language.

THE VOICE.

A SCIENTIFIC STUDY OF ITS FORMATION AND EMISSION, AND ITS AILMENTS.

> Singing is the only art the representatives of which do not take the pains of learning the material rudiments.
>
> *Reynaldo Hahn.*

PREFACE.

« Pitch your voice in the right manner so as to sing in tune, breathe well, pronounce distinctly and your singing will be blameless. » Such is the advice given by Pacherotti to all those who are anxious to study singing.

Though this counsel may seem simple and very easy to carry out, the pupil will nevertheless be soon surprised to find a number of difficulties awaiting him.

Indeed, if he seeks advice from people he believes competent, he will get on each subject so many contradictory answers, that he will hardly be able to find out where lies the truth.

If he wishes to study the question of respiration, he will read in « the Academy of Music's Method » that one breathes in an entirely different way when one sings and when one talks. Breathing during speech does not differ from the normal breathing, during which the air is being renewed in the lungs. In either case the first movement is aspiration during which we inflate the abdomen, its upper part coming somewhat forwards, then we draw it in, this second movement is expiration; these two movements are performed slowly when the body is in its natural state. On the other hand, when one sings, the proper way of breathing is to draw in the abdomen and make it come up again swiftly, at the same time inflating and carrying the chest; when one exhales, the stomach must go back very slowly to its natural position, the chest falling down by degrees so as to keep and economise as much air as possible.

Alerady in 1775, *Bernacchi,* of Bolona, had pointed out that : « inhaling took place without inflating the abdomen. The latter inflates during the respiration when one speaks, and falls back during the respiration when one sings. The chest rises all of a sudden and falls in the same way when one speaks, whereas it rises and falls by slow degrees when one sings. »

Another author informs us that : « before contracting the midriff one should inhale by contracting the muscles of the anterior wall of the abdomen, so as to produce hollow on the level of the stomach. »

The above counsel of breathing by making use of the upper or lower ribs to the exclusion of the diaphragm, has led *Lemaire* and *Lavoix,* the younger, to express their astonishment « that so many eminent teachers and singers should have made such errors concerning the principles of breathing, when they had the possibility of observing if their doctrines were according to nature; but this they did not attempt, neither did they remark, while singing themselves, that practice was at variance with theory. »

« This way of breathing is contrary to nature; it creates a great fatigue in the organism of the body; also the restraint it lays on the chest provokes muscular contractions which prevent the production of a full sound, rounded, pure and agreable. »

Lily Lehmann, in her book « *My art of singing* », tells us how she breathes : « draw in the midriff and also, but very slightly, the abdomen, the muscles of which I immediately relax. I do not raise at all the chest, but I open the upper ribs and rest on the lower ones as on pillars. In so doing I prepare a form for the singing, a storeroom for the breath... The midriff is pliantly propped up below and determines the abdominal pressure. The chest, the diaphragm, the closed epiglot and the raised palate form, so to speak, storerooms for the breath. It is only when I begin to sing that I thrust the breath against the throat. »

In « *Science of vocal mechanism* », by Mrs. *Lacombe,* one reads that « when a child is asleep, his breathing starts from his navel and expands from there, simultaneously to both the abdomen and the base of the ribs. But how can one oblige the air to go down to the extremity of the lungs, without bruising or wounding them? (*sic*). This can be secured by means of the following movements : open the mouth to its full height, thereby provoking a slight return of the lower jaw to the normal position it had lost; hindering this return as much as possible, draw in the air to the navel and keep it there by raising to the utmost and entirely expanding the ribs, endeavouring to give them the greatest possible tension, at the same time suspend the breath, then put the mouth back to the

required position and utter the sound of the vowel *beu* opening it very much... Lastly pull down the extremity of the shoulders towards the ground, bring the lower jaw as much forward as possible (these two movements have to be done at the same time, as they are of no avail when executed separately) and carry *beu* on the italian *a*, so as to obtain *beu-a*. This *beu* must come out from the hollow of the stomach. »

We shall now pass on to Mrs. *Meyerheim's* « *Art of technical singing according to italian traditions and common sense* ». One must breathe by means of the *appogio*. What is the *appogio?* « It is the foundation of the voice, the seat of the respiration. When one sings one holds ones breath by means of the lungs, but when one knows to sing, one attacks, one breathes through the abdomen. »

Some extraordinary means of executing the breathing movements, highly recommended by certain teachers, deserve to be quoted.

A professor who pretends to be the inventor of the *horizontal method*, obliges his pupils to lie down on a mattress on the ground, and places on their chest a weight more or less voluminous, making them sing in this position.

A singing-master from Toulouse was accustomed « to bring his pupils on the platform of the column erected the 10th of April, he would make one of them lie down on a bench near by, then would place a block of stone on his stomach and make him utter sounds diaphragmatically. »

Another teacher has invented to place a basin full of water on the abdomen of his pupils, who have to beware and not overturn it. Still another teacher sits down on the stomach of the student. All these various methods seem to be derived from the one familiar to Emperor Nero and reported by Suetonius. According to the latter, Nero, when practising his singing and declamation, used to place a sheet of metal on his stomach, but removed it when he spoke in public. A very well known singing-master advises his pupils « to push as if they were going to the W. C., then to take their breath. »

A teacher has gone as far as to make his sholars wield a stedge-hammer, whilst another, still more ingenious, obliges his disciples to be squatted under a kind of rack, their heads passed between two bars, and held well up. A professor of the French Academy of Music : « the Conservatoire », has invented the idea of making his pupils lift up the piano by one of its feet.

We have been told by a singing-master that, to be able to sing, it was necessary to take the breath from the thorax and hold it as by a stop-work in the abdomen; and the great man completed his explatation by comparing the voice to a lift, breath being the pillar which supports the cage.

The imagination shown by the singing-masters, when dealing with the question of breathing, seems to be still more vivid in the matter of how to place and throw out the voice, at least I have come to this conclusion through what I have heard and read on these subjects :

« Vibrate your mucous membranes. Widen and open your trachea. When you sing make your head full as if it was about to burst. Open your throat not only forwards but backwards specially. Hold the head up and the jaw down. Open the upper jaw (*sic*). Open the mouth by degrees, as the notes uttered become higher (we hope for the sake of his jaw that the pupil is not blessed with a voice of too great a volume!) Do not move the lips. Put them constantly forwards. Twist about. The Si^b is thus caught on the wing.

« Concentrate the sounds on the roof of the mouth or on the teeth; relax the soft palate so as to bring the sounds in the mask. Endeavour to make the sounds pass first through the nose, before guiding them down to the mouth; finally place them in the vestibule of the larynx.

« Carry the palate up, making it supple against the nose, raise the top of the tongue and narrow the larynx; at the same time as you bring it up, pull the vocal ligaments apart from each other, stretching them upwards by means of *i* and downwards by means of *ou*; the soft palate withdraws itself and opens the cavities of the head. » We may add in passing that the author of these lines has felt the necessity of making a note to warn us that « words as the above have been used solely with the intention of giving the clearest possible explanation of vocal sensations, and must not be considered as a scientific statement. » What would the great French critic, *Boileau*, have said to this? Some more advice follows as to the way of attacking tone. To this effect « the breath has to hit the palate on a central point, situated below the highest point which can be occupied by the note to be uttered; this spot combines both strength and depth; its resounds with any amount of energy if the vocal organs are placed in a position sufficiently concentrated. » (*My art of singing.*)

Many professors are of the opinion that the tongue must be curved in, so as to form a hollow and, accordingly, give the following information : « It is necessary when one starts singing lessons to hold the tongue up by means of a convex instrument, a spoon for instance, till this anomalous position can be acquired naturally and kept without stiffening whatever. » To the same effect, the use of india-rubber balls, kept in the mouth, has also been suggested.

Some teachers press back the soft palate with pieces of wood; another gives the following advice : « For the soft palate, make

use by turns of a kind of pestle and of a flat ruler, the latter applied against the middle of the base of the tongue, when low or medium notes have to be struck. To reach the medium and high notes, apply it by turns *in* the veil of the palate by seezing the corners of the tongue with the forefinger tip. Practice on *A*, holding up the opening of the mouth by the means of three fingers superposed between the jaws; then put the forefinger of the other hand flat against the lower teeth and slip the base of the tongue around the finger tip, moving it from bottom to top and vice-versa. (Mrs. *Chaudesaigues.*) » How are people willing to go through such tortures to be found?

To teach his pupils how to go up the scale, a professor of the Conservatoire had invented an original process : he made use of a double ladder. Standing a few steps above his pupil, he would seeze him by the hair and make him climb a step at each note uttered. This method did not appeal to one of the students, a bass with very frizzled hair, so one day he left the class, came back entirely shaven and went and stood at the foot of the (now harmless) ladder, to the great delight of the company!

Instead of trying to make things intelligible by using plain language, the teachers prefer indulging in words without meaning, thus justifying the following appreciation of a musical critic : « these expressions hide the ignorance of the professors, but show more emphatically their insufficiency. »

What is the meaning, for instance, of these words spoken by a professor of the Conservatoire : « Open the larynx and keep at the same time the prop? »

Another singing-master writes : « On the vowel *A* smartly struck at first, then sustained, prolonged, musicalised, I built a register belonging exclusively to the pharynx, called *chest-voice.* In the same way on the vowel *O* I have graduated a palatal register called *voce mista* or *mixed voice.* Lastly, with *I*, I hoist the voice up to the highest register. »

A third teacher writes as follows : « The palatal voice[1], as its name expresses, resounds in the roof of the palate. The vocal breath, sent to the frontal sinus, hits straight on the upper walls of the palate, where it acquires fullness, majesty and softness. These qualities are rendered still more sonorous as the breath passes through the nasal cavities, without making them however enter into vibration. » (*The voice and the mechanism of singing* by *Verdhurt.*)

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[1] This word has been used for the first time by Révial, a professor at the French Academy of Music (Conservatoire). This kind of voice proceeds much more from the head and the nose than from the chest. (*Delprat.*)

In the « *Rudiment for singers* » one reads : « All the mechanism of singing resides in the direction of the breath. This is the right way of conducting the breath. Once the lungs have been filled, the air should be carefully passed over the lower teeth, so that the palate should return the sound, and the air be prevented from coming out through the nose, as this would give the note a snuffing tone and diminish the fullness, which it can only possess if it comes straight out of the mouth. Hold the sound in front, opening and velveting it to render it soft and full; pitch it far before you so as to draw the voice out; press it down and do not leave this support once you have taken it; in this manner your voice will acquire incredible strength; at the same time the sound will not be able to press inwardly either on the throat, the palate or the nose, in a position which would be fatal to its richness, purity, sonorous quality and vibration... » (Mrs. *Hennelle.*)

By what the author of the « *Theory of the mechanism of singing* » writes in his book, it would seem that the direction of the breath is not yet determined when the sound is uttered. The sounds succeed each other by going either up or down : therefore the breath, which gives them birth and links them together, must also go up or down; but here the author, after having pointed out all the strangeness of the rule he is about to express, informs us that the sound must go up and down contrariwise to the ascent or descent of the notes. To ascend one must send the air downwards, and to descend one must send it upwards, for a scale as well as for the closest intervals. If you follow the natural movement, one would proceed differently; in the case if one was singing upwardly the throat would tighten up as one approachs the higher notes, and therefore one would be incapable of reaching sounds, which could easily be produced if uttered singly. In singing downwards, the air would come back in the chest which would fall in. »

According to « *The emission of the voice* » one must attack the sound on the respiration, by holding back the breath, so as to make it pass through the sound, the breath must stay below the sound and sustain it. (*Marie Sasse.*)

« *The Science of vocal mechanism* » shows as follows how to do the emission of sound : « When the general position of the body has been taken, the student will crave in, without exageration, the middle of his stomach, and advance, as much as possible, his lower jaw over his teeth, these must not touch each others, and the back ones specially must never be pressed together. The student will leave a finger space, between his upper and lower big molars, and give the centre of his lower lip the shape of a dripping-board. »

« He will draw back his upper lip, and press it against his side-teeth, arching it by slightly raising it in the middle, thus pro-

longing the soft palate. In that way he will obtain a kind of mouthpiece, which will enable him to conduct the air column and the sound, and drive them straight and far out, without letting them wander through the nose and the frontal sinus. » (Mrs. *Lacombe.*)

I cannot resist the temptation of mentioning what further benefits can be ensured through this method, according to its author: « These movements, whose importance and efficacity I have already demonstrated, if correctly executed, develop and broaden the breast; they force high shoulders down to their normal level; through them the back loses what the chest acquires in width, the waist becomes more slender and the stomach falls in, *however prominent it may have been;* they beautify women and girls, giving their body harmonious proportions; they keep the breast in its natural position, or bring it back to it; after having practised them for some time all female students, without exception, have to widen the top of their clothes to the extent of 15 to 17 centimetres (6 to 7 inches), to take them in in the back, to lengthen them in front and contract the waist. These changements, these improvements, these transformations take place within three or four months. I have obtained them even in the case of mothers over forty-five. » We will not spoil this remarkable piece of advertisement by any kind of comment!

The same subject has been treated in the following way by the author of « *The art of technical singing according to Italian traditions and commonsence.* ». In scales, if one wishes to strike high notes, one must drive back all the breath in the abdomen, making a vacuum as in a pneumatic pipe, so as to give the voice a free passage to the head. It is why I keep repeating that one must sing through the registers *behind the throat and the body,* and never in front. In fact one ought always to sing inwarly and never outwardly. To sing outwardly is to sing without any feeling, nor style, nor schooling, as one sings in the streets. » (Mrs. *Meyerheim.*)

We select out of the same work this pure gem : « One must hold a trill as a horseman holds back a horse about to run away; one must feel the trill not only in the abdomen, but in the sole of the foot.» It is probably to this effect that a singing-master advises his pupils to stand on one leg and lift the other backward, shaking it convulsively, so as to help the execution of the trill.

These quotations are a sufficient proof that singing is taught more in an empiric than a really serious way.

Most of the professors do not show more true knowledge as regards articulation and either neglect it entirely, or then invent some extraordinary means more likely to impede than to improve it. Daily, students can expect to hear such counsels as these : « Do not open the mouth, nor move the lips, but sing as if you were smiling

or yawning. Rest all the time the tongue on the bottom of the mouth, keeping it motionless and well hidden, or else curve it in. »

In « *My art of singing* », one can read : « The position of the tongue must be thus, that it should neither recline on the larynx nor on the epiglot. The larynx and the tongue must be raised and the larynx lowered. To pronounce *ou*, one brings down energetically the tip of the tongue below the lower incisive teeth, by raising the top of the tongue against the palate, and by holding down the larynx below the tongue. »

« The larynx has to be lowered when the top of the tongue cannot be raised any further. This happens often while singing in the higher register; in that case one must place the larynx quite low down and add *ou* to the vowel which is being sung, taking care not to pronounce it in front of the mouth, but behind the nose, where one can feel it vibrate. »

To slur two vowels which are placed either close together or far from each other (?), one must first of all make ones muscles contract as for *é*, then one slips a well articulated *y* between these two vowels. »

Under the pretext of rendering the emission more pleasing to the ear, one takes the habit of modifying the correct enonciation of vowels, changing *ee* in *ai* (*i* in *é*) *ah* in *oh* (*a* in *o*) and, in French, *u* in *eu*.

Likewise some singing-masters advise their pupils to part a silent *e* between two consonants coupled together, so that the articulation of these consonants should be clearer and more elegant. For example, instead of « *plaisir d'amour* » the pupils are taught to pronounce : « p*e*laisir d'amour, or « *eke*lat de la *guer*andeur » in the place of « *écl*at *de la grandeur.* »

What has been mentioned above shows how queer are the personal notions of the majority of singing-masters on physiology. Before closing the subject we will quote a few expressions constantly used by them, and which go to prove still further how little they know about the organs of the voice. For instance : « Lean on the timbre. Put the hat on. Feel the column. Rest on the sonorousness. Swallow the vowels. Bore out the vowels. Pass accross the vowels. Open the window and shut the loop-hole. Put the helmet on. Mask the sound. (*de Martini.*)

But there is better still :

« Send up the air column from the abdomen, so that it should arrive finally to roots of the hair, after having hit the vocal ligaments. »

« Women do not use their larynx to sing, as they possess a tubal voice. » (*Gailhard.*)

« The glottis is entirely useless and ought to be taken away, as it is prejudicial and is the cause of the glottic-voice. » (*Lievens.*)

« The larynx works like a night-cap which turns itself in when the scale is ascendent, and comes back to its proper place when the scale goes downwards. » The author has omitted to say what could be the position of the larynx, if the last note sung was not a deep one!

Only recently, I have learned that one could find in the larynx a series of chords similar to those of the harp and piano, each chord rendering a different note.

After having heard or read all these extraordinary statements, we can easily conceive that a singing-master should have said to one of his young colleagues : « Remember what I am going to tell you, you who are already aiming to become a teacher; I have made money by teaching, the day only when I taught my pupils to sing otherwise than anybody else, and make them do things they did not understand. As long as my teaching was clear and plain I have just lived and that is all. » The same narrator adds that, when dealing with pupils, if they are shown devices which are simple, clear, easy, generally two things happen :

1. If the pupil understands immediately, he believes that he is not learning anything at all;
2. If he makes progress, he is not in the least thankful to his professor. (*Mayan.*)

In his turn, the professor may try to find a plausible excuse if one of his pupils is not a success, as may appear from the following true story. After having given lessons for three years to a young German girl, without any satisfactory result, the teacher, a lady pianist, said to her pupil who had just been recalled by her parents : « This will not do at all. But it does not surprise me : your throat is made to pronounce German and not French. »

All the above-quoted instances, illustrating the queer teaching given by certain singing-masters, easily explain the perplexity of many pupils after a few months study, especially if the wretched victims have had the misfortune of taking lessons with different professors. They are then quite ready to listen to the advice of one of the saviours who know how to restore tired or ailing voices, and even how to bring back a voice which has been entirely lost.

One restorer cures the stretching and distention of the vocal ligaments, the hoarseness and fatigue after singing, the gaps in the voice, and even the singing out of tune, provided it is caused by one bad ear only. But we will let him speak for himself : « When the singing out of tune comes from the bad condition of both ears, it is necessary to consult a doctor, but if it is occasioned

by one ear only, I can obtain a complete cure by means of a personal system, the secret of which I keep for the benefit of my own pupils. (*The art of making a voice* by *Nazat.*)

Another rescuer restores the voice through the theory of the movements of the larynx : (*The voice amplified by the education and reeducation of the muscles of the larynx* by Mrs. *Clericy du Collet.*)

« The theory of the movements of the larynx, applied to the cure and education of the voice, is the result of much personal labour, and if I claim to be its author, it is to be able to defend it against false or dangerous interpretations.

« It gives the singers the solution of the scientific problem of precision in the teaching of singing; to the doctors, it gives the solution of this medical problem; how to cure hoarseness by means of a direct action on the antagonist muscles... The antagonist muscles are those who facilitate the movements when working in a precise and moderate way, or hinders them when acting with too much exaggeration or in the wrong time. »

This professor, whose ideas on physiology are most novel, tells us that she has been able to acquire by constant practice, the faculty of making herself hoarse and getting rid of the hoarseness in the space of a few minutes. « If I attack suddenly *AH* (*A* in French) I actuate the bronchia (*sic*) and immediately the sound is veiled; if I attack with care, I actuate the larynx and the sound becomes clear. »

The same author in her first books speaks of a muscle of which no mention is made in later publications. « This muscle, which is at the same time extrinsic and intrinsic, is called the *cricoïd muscle*, and covers over, at the same time, the articulations between the thyroïd and the cricoïd, and those between the cricoïd and the arytenoïd cartilages, it is bound to the thyroïd muscles and the constrictors, and certainly helps the arytenoïd cartilages to approximate and then to return to their natural position. »

The same author exercises still further her gift of divination : « The muscles work according to the direction of their lengthening and not of their contraction, as was formely believed... For instance, the great muscle stylo-pharyngien, which governs all the back part of the larynx, by its direction only shows, without any doubt, that the vocal movements take place *from above and from rear to front*... Nature is then to prove that the vocal cords must vibrate by a movement *from rear to front* and then from above, and not by a movement from front to rear and upwards. » And the author concludes : « As we can see, the movements of the larynx are perfectly independent from the bronchia, the thorax, the midriff and the abdomen... »

Further, we may read : « The voice must develop itself with closed mouth between the two eyes. »

Dr. *Bonnier* writes : « In what school, in what establishment of what country could such absurdities be taught and patronized and be officially commended? Not only do the singing-masters teach and enforce a physiology of them, as they ignore this they have never studied, but even in the Conservatoire a tuition, defying common-sense and contrary to the wishes of the « *Sociétés savantes* », which are anxious to obtain that the education should be scientific, is officially and unofficially introduced.

One cannot be but bewildered that an under-secretary and a Minister of public Instruction should have authorized the teaching officially of such empiric methods, in an establishment for higher education. If anything similar should take place in a common-school, immediate action would be taken against the offender. One is entitled to wonder what responsibility the committee of studies has in this state of affairs.

It was whilst reading a book about *the Unity of the voice*, that the idea occurred to the author of *the theory of the larynx movements* to try and cure the singing cripples.

Before developing his doctrine, the author warns the beginners that, to fight the natural and genuine tendency of sliding down the bent of the voice once they have started to sing, they must imagine when they go up the scale that they are singing downwards, and when going down that they are singing upwards.

Which is this method disclosed in the book on *Unity of the voice*? It is *the adhesion by reflex motion.* (*Habay.*)

« The method of adhesion by real reflex motion, in other terms the method of weighing down completely the voice through a reflex movement of the will, consists essentially in translating the unity of this prop form, from the inside, where it is immediately realized by the sonorous column, to the outside by the means of a sign which gathers it up and keeps it under volition. »

The author is careful to add that he believes it necessary to give a few more explanation for the benefit of the Students : « The full explanation of the particularized expression : *adhesion by reflex action* » is that the sonorous pillar in coming out of the distributer, the larynx, must immediately take a general stay, that is adhere entirely to the pharynx and the mucous membranes of the buccal walls. Firmly set, as previously mentioned, the sonorous pillar is at first motionless, *considered as docile matter* of the real reflex action, that is of the will reflected upon the muscles and the different organs which afterwards set this matter [1] in motion, either depressing or

[1] In itself.

dilating it, thereby producing external manifestations which vary in quantity accordingly, and are improperly called : « rising voice and descending voice », etc... These appellations are due to the well-known paralogims already mentioned by me, in connection with the expression which intends to establish that there are really different varieties « *of voices* »; these two errors which make only one in fact, are borne of the same sluggishness, which soon becomes incapable of discerning unity and immoveableness from this actual cause, amidst the succession of unequal results to which this unequality alone gives the appearance of mobility; therefore one gets accustomed to believe that there are *essentially* different positions « in each voice » and that there is also an essential variety « of voices as compared the ones to the others ». We must now come back to the subject of the sonorous pillar of which we have already explained the position. We cannot compare it better, half-stopped as it is between the two movements *steady* in a way, of endosmose and exosmose (inspiration and expiration) than to a *half sliding* ladder placed between a foot and a top which are both immovable. Under the influence of this inner rhythm, the sonorous pillar acquires the necessary preparation and the ductibility to guild pliantly to the rudiments of vocal education (considered in its wider signification). »

I can understand that in reading this extraordinary « pathos », when words are used to express physiological phenomena unknown to the author, the writer of the preface considered it desirable, to warn us that the many readers would find some difficulty in understanding or interpreting correctly the meaning of the expression : *Adhesion of the voice and the sound.* The word *adhesion* here must be understood under its physical, and not its medical meaning. Here it expresses the point where the air column, cast by the pulmonary propellers (bronchia, trachea, etc.), finds its point of resistance and consequently its fulcrum.

« Where is this point? It is situated in the cavity of the pharynx and on all the upper mucous membrane of mouth and nose. In reality it is there, and not on what one is accustomed to call the vocal cords, that the sonorous wave finding its stop, or point of adhesion, breaks itself in different branches spreading into the open by the lips, and forming the multitude of sounds under the influence of the reflex action, set in motion by the will. There, as in physics, we find the momentary intimate union of two volumes by their surface. The first volume is constituted by the emission of gas which gives the propelling force to the phonetic column; the second volume is constituted by the mucous membrane of mouth, nose and pharynx of which the continually wet surface attracts and fixes momentarily the surface of the sonorous column, obliging the latter to break itself up more or less and spread out in the mouth and outside. »

This is the explanation one finds in the preface. But the author of this preface might have told us too, in what way respiration can be compared to the phenomena of endosmose and exosmose, as we were not even aware of the existence of two liquids of different density inside and outside the pulmonary tree (vesicles, bronchia, etc.).

We believe that it is useless to quote any more works concerning song. They have been written by professionals who make use of technical terms which expresss generally internal sensations, not well defined as a rule, or by others who prefer keeping their pupils in utter ignorance as regards the organs of phonation.

Duprez, in his « *Art of singing* », is not afraid to write that it would be out of place and even painful to give, in a treatise of that nature, a scientific and physical definition of the larynx, the trachea, or the lungs. As a poet to compose verses does not need to be acquainted with the physiology of the brains, so it is not necessary to know the anatomy of the vocal organs to be able to sing. »

If one carries this principle still further, one can as well say that a singer does not need to know anything about music, not even how to read it, as he could be able to learn the tunes by hearing them repeatedly played on the violin.

However it would not be unnecessary to notice, with *E. Fournié*, that « those who proclaim the inutility of this knowledge are the first to teach a science of their own, in words of their own, the application of which are too often deplorable. The false science has its special methods and manœuvres which are applied indistinctly to all, without any notice being taken of the personal aptitudes; it is a kind of regular channel through which all the voices must go. If the passage is easy, all is for the best; but if it be long, painful, impossible, the instrument must break or be thrown aside. »

Stephen de la Madelaine is of the same opinion. He says : « All singing-masters ought to take the pains of studying the anatomy of the organs, which cooperate to produce the phenomon of the voice; besides the advantages they would coin through this study, the result of which is to throw valuable light on the mysterious lucubrations of nature, they would discover also the existence and the causes of certain organic connections which it is useful to know, so as to avoid disadvantages or to render their effects profitable to art. »

Battaille relates : « I have often heard people say that great singers had been formed in all times without the help of anatomy. This is perfectly true. However nothing proves that, in a country and in a period where physiology was greatly in favour, the old italian school did not draw from this science some of the elements

of its precious didactics, especially as the traditons of this illustrious school are too learned to be borne only of experience. On the other side in our times, the study of physiology could have preserved many celebrated voices broken too soon. Finally in the matter of education, one is never justified in preferring chance to precision, instinet to accurateness, and routine to science. »

The doctors have constantly proclamed the utility for the singers of physiological knowlegde. The latter feel so much the need of it, that there is not one singing-master who does not possess a special theory on the mechanism of the organs of phonation; unfortunately each theory is false, being founded, as I have already explained, on inner sensations and complete ignorance of anatomy and physiology. Acknowledging the fact, *Rameau* has written that « the teachers have always developed the liking for singing, without thinking much about the means by which to arrive to proper execution; it is not astonishing therefore that there should be so few good singers in France, considering that they are only due to chance. » *Stephen de la Madelaine*, in his turn, recognizes that it is not astonishing that the science of singing has not enriched itself, as many all other sciences have done, through the observations of all the teachers who have been succeeding each other. » He observes that, on the contrary, purely musical teaching has made indisputable progress.

We are obliged to recognize that these criticisms are exact.

« All the professors who teach clarinet can play the clarinet, writes *Melchissédec*, but curiously enough, most singing-masters are incapable of singing any more; they have never known how to sing, or have never been able to do so. It is a fact that one becomes a singing-master nowadays in perfect freedom, without any kind of examination or possible control. »

One of our best known artists for his talent and his spirit of criticism judiciously remarks : « To be a singing-master it is sufficient to have a pupil. » « What the professor does is only to disclose his vocal habits either good or bad, habits which, in his eyes, are nearly always undeniable principles, and the result of a conception which makes him an unique personality. Each teacher creates for himself a kind of physiology of the voice, without any sort of serious basis : he has his own words, his own phrases, and he delights in them. »

« With the exception of the big drum, the tymbals, the triangle (one learns to play the drum) all instruments have one respective method, practical, clear, definitive; there are nearly as many singing methods as there are singing-masters, and all the methods contradict each other. » (*Melchissédec.*)

Pougin writes : « Each teacher has his own method for placing

the voice, for uttering the sound, for breathing, which is quite different from the one of his neighbour. There is no unity of action or of procedure, and consequently none either in regard to the transmission of advice; whereas instrumental teaching is always based on a sacred tradition, on a grouping of excellent precepts which have never been forsaken, it seems on the contrary that the tuition of singing has no other rule than chance, no other foundation than the temperament or the whim of this or that professor : singing is taught in a purely empiric way, without any fixed basis, without even semblance of any kind of doctrine. »

It is quite certain that in France the teaching of singing does not rest on any scientific principle; its basis, its characteristic is empiricism. We are obliged to confess, with *de Pawlowski*, that : « there is no regular singing education in our country. »

Therefore when one sees the insufficiency and defects of the teaching, one cannot be surprised that every year the want of artists is increasingly felt.

For instance if we take the « Conservatoire », we see that each year this establishment recruits out of a great number of competitions, the ten to fifteen vocally better gifted ones; at the end of the year the more eminent of these are rewarded. Now if we require what has become of these laureates, only ten years after they have left the school, how many do we find have made a successful career, and how many more have already been obliged to leave the stage? It is true that most of the latter have become professors; unable to sing anymore, they teach the others how to sing. I leave to the sagacity of the reader the task of appraising the value of the results obtained by this Institution which, during a period of ten years, has trained one hundred and fifty chosen voices and produced so very few artists.

« It is not mere chance if the great number of our singers lose their voices after a few years, when the Italian singers of the old school kept theirs indefinitely. » (*G. Bertrand.*)

Berlioz, struck by the results of this deplorable teaching, had said : « A singer, man or woman, able to sing sixteen bars of good music with a well pitched and sympathetic voice, and to sing them without effort, is a rare bird, very rare, extremely rare. »

The critics of to-day are of the same opinion; this is what was written, after a competitive examination, by one of the members of the jury :

« Without any doubt, there are in the « Conservatoire » a few sagacious and prudent teachers who do not destroy the voice of their pupils, and who are even able sometimes to teach them how to pitch it correctly. But such is the state of the teaching, that even these moderate results seem not far from miraculous; each time that in an

examination a voice is heard which neither trembles nor breaks down, the praises of the teacher are loudly sung by every body. Really, one is too easily satisfied if one admires exceptions which ought to be the rule. In fact the tuition of singing needs badly to be reorganized. »

This sound reflexion is the confirmation of what *Delprat* wrote at an earlier date : « In the « Conservatoire » of Paris, in the theatres, in the drawing-rooms, in the concert-rooms, everywhere, singers quaver in the most detestable fashion. The evil has become chronic and universal. »

Quavering is so usual that when I pointed out to a singing-master, during one of the last examinations of the « Conservatoire », how many competitors quavered, he, with the gravest gravity, assured me that it was only pathetic vibration!

All those who are interested in the art of singing have been emphatically demanding for years past, that changes should be introduced in the teaching given in our school of Music.

Already in 1864, *Stephen de la Madelaine* had written : « One is really disheartened when one examines the actual conditions of the education the singers receive in France. The evil is everywhere : it is deeply rooted; those who are the cause of it and derive benefit from it, live in peace with the world and themselves, and enjoy quietly the profits of their detestable charlatanry, whilst their victims seem to be blinded to everything and even to delight in their delusion. »

Since then complaints have been unceasing. Every year critics write about the deplorable teaching which is given to the pupils; but routine is ever there to prevent, through sheer inert force, any alterations from taking place.

In 1915 however, an Under-Secretary of State for Fine Arts, Mr. *Dalimier*, did bring to notice that all was not perfect in the education given in the « Conservatoire », and tried to introduce some reforms.

In his report to the Minister of public Instruction, he stated that it was primordial that every singing-master should possess the necessary requirements to be able to teach. Is this not an avowal that certain teachers have been found inefficient or incapable, for to know how to teach it is not enough to know how to sing?

But for the weakness of the teaching, Mr. *Dalimier* has only one remedy proposed : instead of being definitively appointed from the day they came into office, the professors would have to undergo a two years probation so as to prove their capacities; those only who succeeded in standing the test would keep their post.

To this suggestion one can reply by one question. What would be the condition of the teaching if, during a certain length of time,

only incapable professors should succeed one another every two years?

Why not institute an examination whose diploma would give the right to teach, as is the custom for all the other schools? In this manner empiricism could have got to disappear.

Is it asking too much of the teacher whose task it is to train voices, to know at least the mechanism of the organs of phonation? Has not the workman studied his engine before using it? Does not the music-master know the instrument he teaches? Why should it be different for the singing-master?

He ought to have a sufficient knowledge of acoustics and phonetics, and of the anatomy and physiology of the vocal organs. It is only natural that he should know what is vibration, pitch, intensity or tone, as well as respiration, emission and articulation of the sounds. Thanks to experimental phonetics he would be able to register the voices of his pupils, and then show them clearly both their defects and their qualities. We think too, that it would not be superfluous to require of them some knowledge of music and singing and, in certain cases, of staging..., for I remember a conversation which took place before a professor of lyric declamation, who had just been named, and a friend of his, the latter being obliged to give him full information about an opera, out of which one of his pupils had chosen to sing a scene for an examination.

I can but hope that these reforms may take place in the near future. In the mean time, I can state that the idea of controling the tuition given at the « Conservatoire » by means of experimental phonetics, has already been partly realized. In answer to my proposal, « Mr. le Sous-Secrétaire d'Etat aux Beaux-Arts » has appointed a commitee to the effect of carrying out this method; the commitee has recognized its utility, but has decided to have recourse to it in exceptional cases, only when the members of the examination and the professors would not agree. For the present, it seems difficult to ask the latter, as they are on the committee, to submit themselves to a control which could bring upon them the condemnation of their methods.

Meanwwhile we must take patience, and hope that, in the end, common-sense will win over empiricism.

It is in that hope, that I am offering my modest contribution in regards to the rational teaching of singing. I have at least tried to make as comprehensible as possible the rather fanciful explanations, which have been till now in vogue in the singing world.

CHAPTER I.

THE VOICE.

The voice is a sound produced by the working of several organs, called *organs of the voice* — or organs of *phonation.*

The lungs constitute the motor element; the larynx is the organ where the sound is formed; the pharynx, the nose and the mouth are the cavities designed for its emission and timbre.

Breathing.

Anatomy and physiology. — The lungs are the essential organs of breathing.

We shall leave aside respiration considered as a function of nutrition, and we shall just bear in mind, that its object is to bring into the blood the oxygen from the air, at the same time as to rid it from the carbonic acid, residuum of the combustions which take place inside the tissues and the organs.

What is of greater interest, for those who are by profession voice-users, is the motor function which produces the breath necessary for the emission of tone.

Before arriving to the lungs, which act as bellows in the breathing, the air passes through a continuous series of cavities : the nose, the cavities or chambers of the nose, the pharynx, the larynx or voice-box, the trachea or windpipe, and the bronchi to reach at last the pulmonary cavities.

The *nose*, which is situated at the entrance of the organs of breathing, offers two apertures : the *nostrils* (Fig. 1, *a*) of which the anterior opening, facing down, is placed on a lower level than the floor of the nasal chambers. The axis of the nostrils is vertical, whilst the axis of the nasal cavities, contrary to the popular opinion, is antero-posterior; the effect of this disposition is to change the direction of the air current, from the moment it enters the aerial tube.

The *nasal cavities* and their accessory cavities, the *sinus*, fill a great space in the facial cavity; the sinus which are divided in *maxillary, frontal* (Fig. 1, *s*) and *sphenoïdal sinus* (Fig. 1, *K*) are disposed by pairs, on either side of the antero-posterior line of the skull.

The nasal cavities of the nose are separated from each other by a median and vertical blade called the *partition*, and present laterally bony blades : the turbinated bodies (Fig. 1, *i, m, s*) which curve themselves in, inside the nasal cavity, towards the partition, without however reaching the latter. The floor of the nasal cavities is constituted by the *hard palate* which is bony, and by the *soft palate* which is membraneous, both contributing to separate the cavities of the nose from the mouth; to the soft palate is attached the *uvula* consisting of a muscle, *azygos uvulæ*, and which has power of shortening, elevating and retracting it.

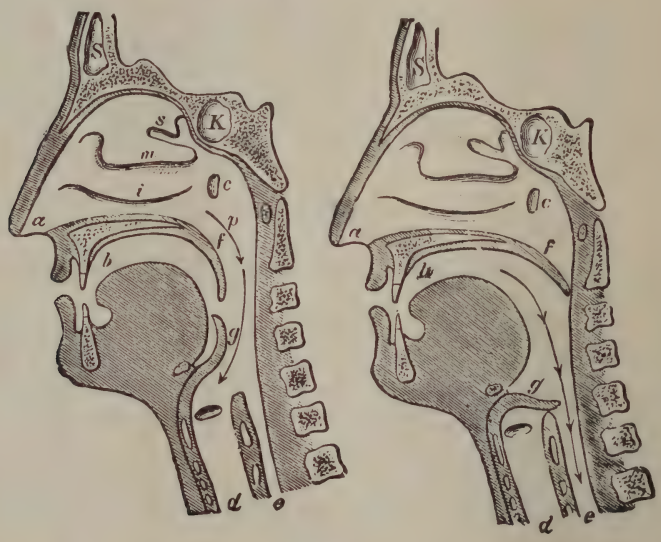


Figure 1.
Section of the head passing through the antero-posterior axis of the skull.

A. Pharynx in breathing : the soft palate is lowered. The direction of the air current is shown by the arrows.

B. Pharynx in deglutition. The communication with the nasal cavities is shut up by the raised soft palate, and the communication with the trachea is empeded by the epiglottis.
The course of the aliments is indicated by the arrows.

a nostrills. — *b* buccal cavity. — *c* aperture of the Eustachian tube leading to the middle ear. — *d* trachea. — *e* gullet. — *f* soft palate. — *g* epiglottis. — *S* frontal sinus. — *K* sphenoidal sinus. — *s, m, i* upper, middle and lower turbinated bodies. — *p* nasal pharynx.

The cavity of the nose is entirely lined by the pituitous mucous membrane which secretes the nasal mucus.

In children, the cavities of the nose are proportionnally bigger than in adults. The face, in developing itself, lengthens, the nose grows longer and the nasal cavities get narrower, in proportion to the enlargement of the horns.

The nasal cavities lead backwards to the upper part of the pharynx, which is called *nasal pharynx* or *post-nasal cavities.* As shown in figure 1, *B*, the nasal pharynx is separated from the buccal pharynx by the soft palate, *f*, when the latter is raised as will be explained later.

The mouth, which is separated from the nasal cavities by the hard palate and the soft palate, is placed before the *buccal pharynx,* and is bounded in front by the lips and the incisive and canine teeth, and at the sides, by the molar teeth and the cheeks.

On either side of the soft palate, from which centre hangs the *uvula,* there is a kind of double curtain, called the *anterior* and *posterior pillars,* between which is placed the *tonsil.*

The anterior pillars contain a pair of muscles, *palato-glossi,* which by their contraction straighten and tighten them, thereby bringing them closer together, and narrowing the space between them called the *isthmus of the fauces.*

The posterior pillars contain another pair of muscles, *palato-pharyngei,* which, by their contraction, approximate the posterior pillars of the fauces and narrow the space between them.

The floor of the mouth is formed by the tongue whose anterior and horizontal portion corresponds to the hard palate, while its posterior and vertical portion is turned towards the lower part of the buccal pharynx.

The tongue is attached by its base to a bow shaped bone : the *hyoid bone,* which is situated at the upper part of the neck, parallely to the horizontal branch of the jaw. As this bone is fixed to none other, it is exceedingly movable.

The tongue is an organ formed of muscles which are covered by a sheath of mucous membrane. Those muscles are inserted into the surrounding parts : maxillar, palatine, hyoid bones and pharynx, thereby enabling the tongue to move in all directions and to take different shapes, according to the various needs. At the base of the tongue, against the epiglottis is the *lingual tonsil.*

The function of the membranous portion of the soft palate is to close the communication between mouth and nose in the deglutition, and to open it in pronouncing the nasals *an, in, on, un* (*french nasals*) as shown in figure 1. The closure, between the buccal pharynx and the nasal pharynx, is still further completed by the cooperation of

the uvula and the pillars of the fauces, coming to rest closely upon the posterior part of the pharynx, which is none other than the spine covered over by the muscles and the mucous membrane.

In breathing, the soft palate hangs in the pharynx (Fig. 1, *A*).

Consequently, the buccal pharynx can be compared to a kind of cross-road where the digestive and aerial tubes cross each other.

The pharynx is continued below by the larynx.

The larynx is composed of : 1° a mobile cartilage : the *epiglottis* (Fig. 1, *g* and Fig. 3, *E*) which is joined to the base of the tongue and the thyroid cartilage. At certain times, during deglutition, its function is to separate the air canals from the digestive canals, thereby preventing the food from entering the larynx (Fig. 1, *B*, *g*). The epiglottis has also a function in phonation.

2° Two other large superposed cartilages : one, the *thyroid* (Fig. 2, *A*) which is shaped like a shield flattened on the sides, prominent in front, and forms in the throat *the « Adam's apple »*; the other : the *cricoid* has the shape of a signet ring (Fig. 2, *B*), the bezel of which turned backwards, carries two other

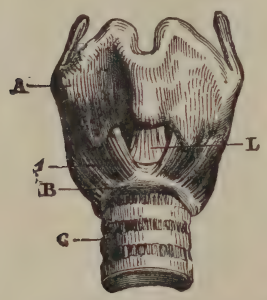


Figure 2.
Larynx seen from its anterior face. *A* thyroid cartilage. — *B* cricoid cartilage. — *C* trachea. — *L* crico-thyroid ligament. — *M* crico-thyroid muscle.

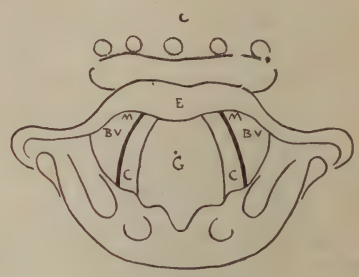


Figure 3.
Interior view of the larynx. *L* base of the tongue. — *E* epiglottis. — *C* vocal cord. — *B V* ventricular bands. — *C M* Entrance of the ventricle of *Morgagni* (darker line). — *G* glottis.

small cartilages, with triangular bases and tapering tops after the fashion of a pyramid, these are called *arytenoid cartilages*. On the anterior corner of their triangular base are inserted the vocal cords (Fig. 3, *c*) which are attached by their front ends to the posterior face of the shields (thyroid cartilage) re-entrant angle.

The vocal cords, or vocal band, present a whitish coloration; they are formed by a fold of the laryngeal mucous membrane, and leave between each other a space called *glottis* (Fig. 3, *b*). As the arytenoid cartilages are capable of moving in all directions upon the cricoid cartilages, either by being shifted forwards, or drawn away from each other or towards each other, it can be easily under-

stood that the vocal ligaments have to follow their movements, thus becoming shorter, and opening or shutting the glottis.

The glottis, as aforesaid, is the space enclosed between the inner borders of the vocal ligaments. The portions which are situated above the ligaments are referred to as *upper-glottic*, and those placed below, as *sub-glottic.*

For a long time, one has distinguished a *vocal glottis* and a *respiratory glottis;* the latter corresponded to the portion enclosed between the pyramids (arytenoids), whilst the vocal glottis referred to the ligaments.

Above the vocal bands, which have also been called : *lower vocal cords*, run the pocket ligaments, or *upper vocal cords*, or still *false vocal cords* (Fig. 3, *BV*) which have a reddish coloration, whereas the real ligaments offer a white nacreous aspect.

Between the vocal ligament and the pocket ligament, we see the entrance of the *Ventricle of Morgagni* (Fig. 3, *MC*), kind of pocket or fold of the mucous membrane of which I will speak further.

The shield cartilage is joined to the ring cartilage, upon which it can sway backwards and forwards, by the means of a ligament : the *crico-thyroideus* (Fig. 2, L).

The muscles which set into action the different laryngeal cartilages, making them move one on the other, are called *inherent muscles;* they are disposed in pairs, one on the right, the other on the left side, and are named after the two cartilages on which they are inserted.

If one looks at the larynx by its anterior face, one sees on each side of the median line, a muscle called the *crico-thyroideus,* which goes from the cricoid to the thyroid. When it contracts it draws these two cartilages together, and sways the thyroid forwards. Therefore this muscle stretches the vocal ligaments.

Between the cricoid and the thyroid, and hidden by the latter, is the muscle called lateral *crico-arytenoideus,* which goes from the side borders of the ring cartilage to the hind projection of the base of the arytenoid. By contracting, it draws forward this projection, at the same time approximating the anterior projections, and consequently the vocal cords, thereby reducing the glottis in width and closing it.

The muscle *thyro-arytenoideus,* which runs inside the cord and lines the wall of the *ventricles of Morgagni,* in contracting shortens the vocal band and reduces the capacity of the ventricles.

If one looks at the larynx from its posterior part, one sees the muscle *ary-arytenoideus,* or *inter-arytenoideus,* stretched out crosswise from one pyramid to the other. It is formed by three muscles, one odd and two even ones, which go from the base of an arytenoid

to the summit of the other. Their function is to draw the arytenoid cartilages together and, consequently, to narrow the glottis.

The action of all the above named muscles is to shut the glottis.

Only one opens it : the *posterior crico-arytenoideus,* which is situated, as implied by the name, at the posterior part of the larynx, on a lower level than the arytenoidei; it runs upwards from the posterior face of the cricoid to the hind projection of the pyramid. When it contracts, it makes the arytenoid cartilage swerve on its axis; by this movement the anterior projection of the base, on which is attached the vocal ligament, is drawn outwards, so as to stretch apart from each other the vocal cords and to widen the glottis; this takes place during deep inspiration.

The laryngeal muscles can be divided in two groups according to their action on the glottis :

1° the *dilators :* posterior crico-arytenoidei,

2° the *constrictors :* arytenodei, lateral crico-arytenoidei, crico-thyroidei and thyro-arytenoidei. These three last muscles are also called *stretchers* of the vocal cords.

A nerve, the *recurrent,* or *lower laryngeal nerve,* innervates all the muscles of the larynx, with the exception of the crico-thyroidei which is innervated by the *external laryngeal nerve,* a branch of the *lower laryngeal nerve.*

Besides these *intrinsic* muscles which have as function, as we have already said, to set into motion these different parts which form the larynx, to stretch or relax the ligaments, to open and to shut the glottis, there is a series of *extrinsic* muscles whose action is to make the larynx move in its totality, by carrying it, according to the needs, either upwards, downwards, backwards and forwards.

Some of the latter muscles have a direct action on the larynx, as the *sterno-thyroideus,* the *thyro-hyoideus,* the *stylo-pharyngeus* and the *lower pharyngeal constrictor* which join the larynx to the adjoining organs : sternum, hyoid bone, pharynx and basis of the skull.

Others act indirectly on the larynx through the intermedium of the hyoid bone with which they are joined; this is the case for the *sterno-hyoideus* and the *omoplat-hyoideus* which go from the hyoid bone to the sternum, or to the shoulder bone, and draw the larynx downwards; and also for the muscles of the upper *hyoideal-region,* which run to the maxillar and raise the larynx.

These muscles, which are the *raising* or *lowering* muscles of the larynx, according as they are attached either outwards, upwards or downwards on the thyroid or the hyoid bone, have in phonation the important function of drawing up or down the larynx, in accordance with the emission of the voice, the pitch of the tone and the articulation of the different vowels.

Following the cricoid cartilage, is the windpipe or *trachea* (Fig. 2, *c*); it is formed of fibrous tissue, inside which are cartilaginous rings, which prevent the walls from falling in during the action of breathing.

At its lower end the trachea is divided into two branches called *bronchi* (Fig. 4, *c*); these subdivide in a series of lesser and lesser canals, ending finally in groups of elastic vesicles which form the two *lungs*. Between these pulmonary air-cells circulate the capillary vessels which are filled with blood laden with carbonic acid; the object of the capillary vessels is to allow the exhange between this foul gas and the oxygen brought in the lungs by the air.

Each lung is shaped as a cone of which the point is turned upwards, and the base, downwards. The lung is enclosed in a double envelop, called the *pleura*, which on the one part covers the

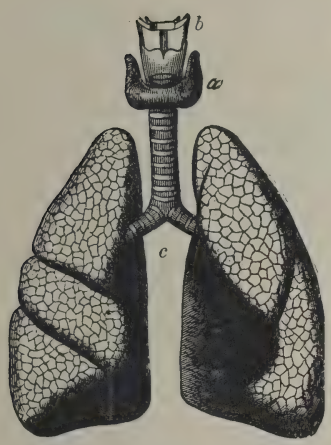


Figure 4.

Trachea, or windpipe and lungs seen by the anterior face.
a the thyroid above which is seen the larynx. — *b* hyoid bone to which the larynx is suspended. — *c* branching-off of the trachea in two bronchi which penetrate the lung.

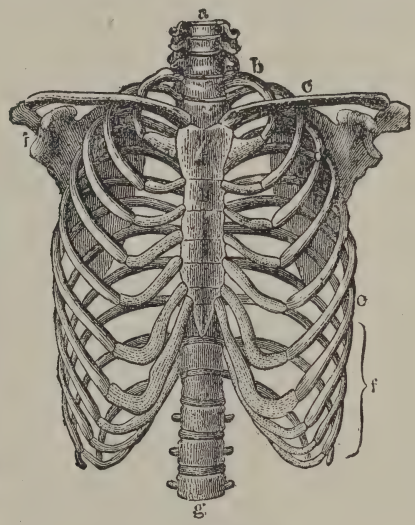


Figure 5.

Front view of the thorax, or chest, *a*, *g* spine. — *b*, *o* the real ribs attached without intermedium to the sternum. — *f* false ribs. — *c* collar bone or clavicle. — *i* shoulder blade or omoplate.

lung and, on the other, forms a lining to the walls of the chest. The interior surface of the pleura is smooth and slightly moist, so as to allow movements without the risk of any friction occurring.

The heart and the lungs fill the chest.

The chest, or *thorax* (Fig. 5), is coneshaped like the lungs which it contains. This bony cone is limited by the *spine* (Fig. 5, *a*, *g*) at

the back, by the *sternum*, or breast-bone (*h*), in front and, on either side, by the *ribs*, sort of osseous bows, which slant from inside to outside, from top to bottom, and from hind to front. In the skeleton they are separated the ones from the others by empty spaces, but in the living body they are joined together by the *intercostal muscles*, which render all the osseous bones binding upon each other.

The ribs which are 12 in number, articulate behind with the spine; but, in front, only the seven first ones are fastened directly to the breast-bone; these are the real ribs (*b*, *c*); the five last ones, which are called the false ribs (*f*), are either floating, or else are attached to the cartilage of the above rib; this structure gives a greater mobility to this lower part of the chest.

The collar-bones, or *clavicles* (*c*), which surmount the thorax, join the brest-bone (*h*) to the shoulder-blade (*i*); this latter is a flat bone, of triangular shape, which applies itself to the back part of the chest.

The top of the cone is shut by the root of the neck.

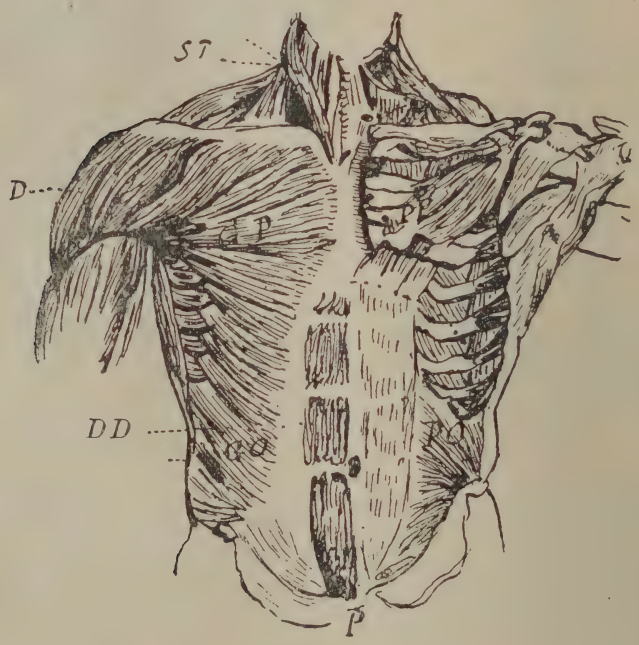


Figure 6.
Inspiratory and expiratory muscles.
S T sterno-mastoideus. — *G P* major pectoral. — *P P* minor pectoral. — *D* deltoid. — *D D* Straight muscles. — *G O* major oblique. — *P O* minor oblique. — *P* pubis.
On the left side of the body, the superficial muscles have been taken away, to show the deep muscles and the ribs.

The *midriff*, or diaphragm, which is a transversal muscle attached to the spine, the point of the sternum, and the two lowest ribs, shuts the thorax below, thereby separating the chest from the abdomen.

To give an idea of the shape of the diaphragm, one can compare it to a copper basin put upside down; it has therefore the appearance of a vault which arches up into the chest, whilst its lower concavity covers over the bowels, the liver and the stomach, all these organs being contained in the abdomen.

The thorax is covered over by muscles; and at the top of the whole structure is the skin.

The muscles have the task of allowing the chest to execute the movements necessary to the respiration. According to their function; they are divided into inspiratory and expiratory muscles (Fig. 6).

Among the principal muscles of *inspiration* we will name :

1° the *sterno-mastoidei* (Fig. 6, *S. T*), which goes from the posterior and lower part of the mastoid apophysis to the collar-bone. In contracting, they raise the latter and in consequence, the ribs.

2° the *major-pectorals* (Fig. 6, *G. P*), which run from the six first ribs to the upper part of the bone of the arm, or *humerus;* these muscles raise the chest when the arms are at rest.

3° the *minor-pectorals* (Fig. 6, *PP*), which, starting from the third, fourth and fifth ribs, fasten themselves on the shoulder or, more exactly, on the upper and outer part of the omoplate; their function is to draw up the ribs towards the shoulder.

The chief muscles of expiration are placed on the abdominal wall. They are :

1° the *straight muscles* (Fig. 6, *D. D*), which occupy the median and anterior part of the abdomen, and go from the breast-bone and the front face of the fifth and sixth costal cartilages to the pubis, that is, to the front corner of the iliac bone of the pelvis.

2° the *major* and *minor obliques* (Fig. 6, *G. O* and *P. O*), which are placed on the sides of the abdomen, and run from the ribs and the last costal cartilages to the pelvis.

Though these muscles are more specially set into action during forced expiration, they are nevertheless made use of to keep the abdomen motionless during the working of the midriff.

Such is succinctly the anatomy of the organs of respiration.

We will now deal with their working in connection with respiration.

Respiration is performed in two actions :

1° the entrance of the air, or *inspiration.*

2° the expulsion of air, or *expiration.*

When inspiration takes place, the wings of the nose, set in motion by muscles, widen so as to let the air penetrate into the nasal cavities, at the same time as the soft palate falls down and the epiglottis is raised.

The expiratory function of the nose has been utterly disregarded for a long time, as one dealt only with its olfactory function, that is with the sense of smell. But nowadays, one knows that only the layer of air, which enters by the anterior half of the nostrils, goes towards the arch of the nasal chambers, where ends the olfactory nerve or nerve of smell, whereas the air layer, which enters through the posterior half of the nostril, reaches the pharynx and larynx, going round the soft palate.

During its passage over the numerous folds of the pituitary mucous membrane, the outside air whose average temperature is 15° (60° Fahrenheit) becomes warmer and moister, and gets rid of the germs and dust with which it is crowded.

Several experiments have been made with the object of finding out if there was any difference of temperature between the air which is entered through the nose, and the air which had come in by the mouth; and it has been observed that there was an interval of about 2° in temperature of the air, according as it had passed exclusively either through the nose or the mouth. For instance, Professor *Grehant* has found that expired air had only a temperature of 33°,9 when the air had been previoussly inhaled through the mouth, whilst air, which had been breathed in through the nose, was at a temperature of 35°,3 when it came out, the outside temperature being 22°.

Furthermore the air, having become moister inside the cavities of the nose, can no more dry up the secretions of pharynx, larynx and trachea, in passing through.

Lastly, the hairs of the nostrils (*vibrisses*) and the cilia which cover the epithelium of the pituitary mucous membrane sift the air, arresting the dust and the germs of outside contamination, which are driven out by both the actions of sneezing and of blowing the nose. Then, in a healthy condition, it is injurious to make use of nasal irrigations, though many people have the belief that by this device they clean their nose and get rid of the impurities which have penetrated into the nasal cavities. By sniffing water, one destroys these cilia which are protective organs placed by nature at the entrance of the air passages; and one is therefore thus running towards the evil which one imagines one is preventing. Also people who suffer from catarrh are more than others exposed to catch affections of the trachea and bronchi.

Having thus been sterilized during its passage through the cavities of the nose, the air arrives in the bronchi, having acquired special qualities of heat and dampness, and penetrates into the pul-

monary vesicles, inflating them, and coming into contact with the capillary blood vessels which surround the air-cells so as to proceed to the exchange of gas necessary to life.

When it has left to the blood the oxygen it contains and taken, in exchange, the carbonic acid, the air is chased from the air-cell, which return to their original form, by reason of their own elasticity and the pressure of the outside air. Thus is restablished, in the parts set in action, the state of rest altered by the inspiration, while the air follows backwards the same way it had taken previously, and comes out finally through the nose.

The respiration is effected in two actions; in *inspiration*, the air arrives in the lungs; on the contrary, in *expiration* the air is expelled from the chest. These two movements follow each other in a regular and rythmical way, without the intervention of the will, during sleep, when the function of nutrition takes place, unknown to us, so to speak. But the will can accelerate these movements which are, in normal respiration, according to a nearly invariable cadence, of 16 to 18 per minute; which means that there is about one complete respiration every four seconds. In a newly-born baby, the number of respirations per minute is about 40, and in adolescents 20.

The first act of the respiration, inspiration, is shorter than the second, expiration; but it is very difficult to precise exactly what is the relation of time between the two movements. In ordinary inspiration, the midriff alone is set into action, and forces back the abdominal organs so as to enable the lung to expand from where it is the widest, that is from its base. In expiration the diaphragm comes up again towards the chest, thus expelling the air from the lung.

The quantity of air which enters inside the chest in that way, would not be sufficient to accomplish the work required by phonation.

If the motive function must take place, the will must come into action, and inspiration must be active and muscular, to the effect of determining the expansion of the thorax in all directions; this result is reached by drawing apart the base of the chest from its summit, and by opening its lateral walls, so as to obtain a general increase of the diameters in antero-posterior, transversal and vertical directions.

The antero-posterior and transversal diameters are enlarged by the movement of the ribs, of which the fixed fulcrum is behind on the spine, and the movable point, forwards on the breast-bone. In rising, the ribs carry forward the sternum, away from the spine, thus lengthening the antero-posterior diameter.

Furthermore, when the ribs, which slant from inside to outside and from top to bottom, are raised, their convex part is carried outwards, thereby increasing the transverse diameter of the thorax.

These movements are produced by the contraction of the inspiratory muscles.

As to the lengthening of the chest's vertical diameter, it is caused by the contraction of the diaphragm which is drawn down more than in ordinary respiration, with the result that the organs contained in the abdominal cavity are pressed more in; the midriff has then partially lost its arched shape, and the cavity of the thorax and the lungs have expanded in the space left free by the lowering of the muscular diaphragmatic partition.

To produce the tone, one cannot just be contented with ordinary expiration, one must have recourse to forced expiration, which is active and the result of the contraction of the expiratory muscles, the latter provoking the compression of the lung and increasing the speed of the air current.

Respiratory air, supplemental air, complementary air and residual air. — The amount of air, which goes in or out during ordinary respiration, is called *respiratory air*, or *current air*.

It is generally admitted that respiratory air can vary from 500 to 600 cubic centimetres, viz. a little more than half a litre, according to the condition of inspiration and expiration in each individual, and also to the greater or lesser amplitude of these two acts.

Thus, in a minute, about eight or ten litres of air pass through the lungs, viz. 500 litres per hour, this is what one calls *air circulation*.

If, after an ordinary inspiration, one continues to inhale as deeply as possible, by setting into action the inspiratory muscles, that is by taking a *forced inspiration*, one can still bring into the chest about 1,500 to 2,000 cubic centimetres; a man can even inhale nearly 5 litres, and a woman, from 1 to 4 litres at the utmost. The air inhaled in this manner is called *complementary air*. It is generally admitted that a forced inspiration brings into the lungs an average of 1,600 cubic centimetres of complementary air, besides the 500 cubic centimetres of respiratory, or current air, already brought into the lung through normal inspiration.

Likewise, at the end of an ordinary expiration, one can still eject a certain quantity of air from the chest through forced expiration; this amount of air, rated from 1,500 to 2,000 cubic centimetres, or 1,600 on an average, is named *supplemental air*, or *respiratory reserve*. Supplemental air is therefore the volume of air which can be ejected from the lungs, after an ordinary respiration, through active expiration, by means of the energetic contraction of the expiratory muscles.

Supplemental air is nearly the same in volume as complementary air, and consequently averages 1,600 cubic centimetres.

When current air and supplemental air have been ejected from the lung, there still remains in that organ a certain quantity of air, which goes by the name of *residual air*, and cannot be driven out even by the deepest expiration. It can only go away when the lung empties itself entirely, as for instance after a wound which perforates skin and lung.

In the abstract, the lung of a male adult can contain :

1. A constant residual air	1,100cc
2. A normal, or current air	600cc
3. A respiratory reserve, or supplemental air, which is ejected only through forced expiration	1,600cc
4. And if one makes a deep inspiration, a complementary air	1,600cc
Which makes about 5 litres.	

Let it be noticed that this figure of 5 litres doest not represent the quantity of air, which can come into and out of the chest through exaggerated muscular effort, as the residual air stays always in the lung.

The *vital pulmonary capacity* (*Gréhant*) is the amount of air contained in the chest at rest, that is after an ordinary expiration. It is therefore composed of :

supplemental air	1,600cc
residual air	1,100cc
that is	2,700cc

or more exactly, of 2,735 cubic centimetres in a man, and 2,547 cubic centimetres in a woman. (*Grehant.*)

The *vital capacity* (*Hutchinson*) or *breathing capacity* (*Grehant*) is the amount of air which comes out of the chest, when, after a forced inspiration, one makes an exaggereted expiration by completely exhausting the action of the expiration muscles. It has an interest, specially for those who are professional voice-users. It includes :

respiratory air	600cc
complementary air . . .	1,600cc
supplementary air . . .	1,600cc
that is	3 litres, 8, in average

which many singers are far from attaining, as this matter will be referred to in the chapter of spirometry.

The vital capacity varies according to the age, the height and specially the thoracic perimeter.

The following table gives a summary of these different measurements [1] in an adult.

MEN.

Chest girth	Weight	Vital capacity	Height
86	70,7	4,40	177
86	69,7	4,29	176
86	70	4,35	175
87	70,3	4,56	174
87	73	4,17	172
84	64,7	3,86	171
84	65	3,91	170
84	63	3,85	169
82	61	3,55	165
81	59,4	3,32	164
82	58,7	3,49	163
82	58,3	3,41	162

WOMEN.

Chest girth	Weight	Vital capacity	Height
75	58,5	3,05	162
75	58,5	3,26	161
74	58,5	3,03	159
72	55,2	2,68	155
74	55,3	2,72	154
71	53,6	2,39	152
72	53,6	2,49	151
71	51,9	2,36	149
70	53,2	2,51	147

This information is borrowed from the data collected by the Anthropometric Committee (Société d'anthropologie) (T. VI, n° 5).

It may be observed that the results obtained in France are inferior to those which have been found in England, when individuals of equal size are considered. This can be explained by the conditions of inferiority in which we, French people, found ourselves as regards sports, when these tables were drawn.

Any kind of constraint in breathing lessens the pulmonary capacity; on the contrary, the latter is increased by movement.

The amplitude of the thorax varies according as the individual is lying on the back, the side, or the chest. It is obvious that in the last cases, the action of muscles and ribs is impeded.

[1] In french measures.

When one is seated one does not breathe as well as when one is standing; the shape of the thorax is altered by the execution of certain movements, like the raising and folding of the arms, or the turning of the body sideways, etc. The amount of air expired has been examined in some of these postures.

If one represents by 1 the volume of air expired in the dorsal decubitus, that is in the horizontal position, one gets the following figures (*Smith*).

Dorsal decubitus	1
Sitting posture	1.18
Reading	1.26
Erect posture	1.33
Slow walking	1. 9
Quick walking	4
Running	7

Singers and speakers are obliged to breath well and to ascertain facts concerning this, without having recourse to a direct examination of the organs, one must take the measurement of the lung capacity, of the thoracic perimeter and of the perviousness of the nasal cavities.

Nasal aerometry or rhinometry. — Thus is called the measurement of the perviousness of the nose to respiratory air.

To estimate this permeability, the quickest way of proceeding, which is also very primitive and often incorrect, is to shut one nostril by pressing a finger against the wing of the nose, and to blow several times through the other nostril. One makes thus a series of sudden inspirations and expirations which give an idea of the nasal perviousness; with some practice, one can easily recognize that the sound made by the air, passing through the nasal cavities, is so much the deeper as the cavity is roomier and freeer; contrariwise the sound is schriller when the nasal chamber is obstructed.

Eeverybody knows the simple means of appreciating the strength of the air current, by applying the back of the hand underneath the nose; this proceeding is inaccurate and can offer some inconvenience for the experimenter, if the patient has omitted to blow his nose beforehand!

These means of ascertaining the degree of permeability of the nose are of doubtful value, for if the air, which ought to come out through both nostrils, passes only through one, it is obvious that the sudden expiration acquired by this experiment does not correspond to the breathing of the patient, as most of the current air comes out through the mouth.

As result of the well known experience of the condensation of the vapour on a cold pane, when one projects on it the expired air, saturated with steam, and at a temperature of about 37°, when it comes out of the mouth and the nose, to avoid the above-mentioned drawbacks, the idea has been conceived of using a glass plate.

Zwaardemaker places horizontally below the nostrils a mirror, on which the expired air leaves two spots of reek, named by him, *breathing spots*. The image, which is single at first, becomes double when the reek evaporates; the vapour disappears at first by the median part, which corresponds to the under-partition of the nose.

After *Czermark* and *Passavant*, *Glatzel* makes use of a quadrangular shaped sheet of metal covered with nickel, and presenting on two sides a notch for the admission of the upper lip. On the sheet, there is a graduation in half circles for the measurements of the spots.

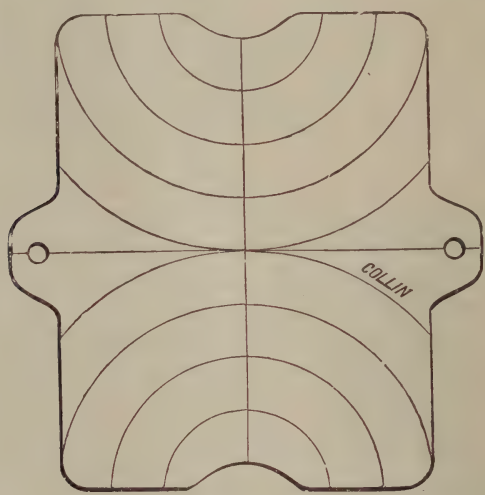


Figure 7.
Glatzel's mirror.

The patient begins by blowing his nose, so as to get rid of the mucosities which could stop it; then he takes a few regular respirations; at this moment *Glatzer's* mirror is placed against his upper lip, and is left there during two or three respirations. A spot appears on the mirror if the nasal cavities are free, it spreads till the fourth arc of circle, but stops lower and disappears quicker if they are obstructed. If the spot produced on one side is smaller and evaporates more rapidly, it is a sign of stricture of the corresponding nasal chamber.

One can also measure the amount of air which passes through the nose by making the patient expire by each nostril in turns, into a graduated spirometer, or better still by both nostrils into two separate apparatus; unhappily this method is somewhat too complicated to be used currently.

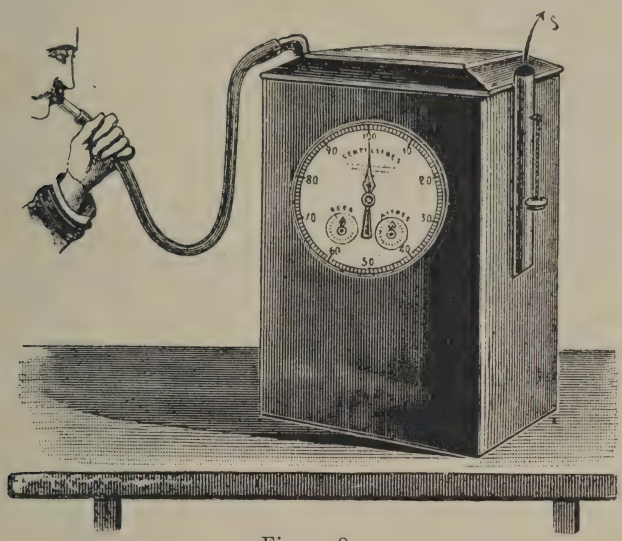


Figure 8.
Verdin's spirometer.

Spirometry. — For measuring the amount of air expired, use is made of apparatus called *spirometers.*

Many of these are built according to the system of the gasometers (*Hutchinson, Vogel*), or of hydraulic gas-meters (*Scholefield, Forstmann, Verdin*), others are based on the principle of Mariotte's vase (*Dupont, Joal*), or on the one of the dilatation of a vulcanized india-rubber bag (*Boudin, Binet...*).

One of the simplest spirometers is, beyond doubt, the one of *Verdin* (Fig. 8), which works like a gas-meter.

This instrument is easily used. First, the patient is requested to take a forced inspiration, then to place between his lips the glass tube, which is joined to the spirometer tube, and to make a forced expiration, but, at the same time, being careful that the expired air does not escape between the glass tube and the lips, as in that case the indicator hand of the dial would not tell the exact volume of air expired.

In this manner, one can find out the breathing capacity of the patient and, consequently, the quantity of air the singer can dispose of to produce the tone.

If one wishes only to know the amount of air contained in the chest while at rest, that is if one wants to measure the pulmonary capacity or, in other terms, to find out how many litres of air come into the lung with each ordinary respiration, it is necessary to request the patient to neither inspire or expire forcedly.

After each experiment, the hand must be brought back on zero, as shown in figure 8.

Dr. *Joal* has made a certain number of researches on patients, who, he believed, breathed incompletely, through either clavicular, lower thoracic or diaphragmatic respiration, according to the parts of the thorax set in motion. He is of the opinion that clavicular, or collar bone breathing gives the lesser vital capacity (and there is no doubt, about considering the lack of development of the lung at this particular point where the chest is at its narrowest). Then, would come diaphragmatic or abdominal breathing, in which the diaphragm only intervenes; and finally, costal or lower thoracic breathing, as shown by the following table, drawn up after experiments made upon three artists familiar with all three modes of respiration.

	Clavicular breathing	Diaphragmatic breathing	Thoracic breathing
1	4,600	5,200	5,300
2	4,000	4,300	4,800
3	3,700	4,000	4,300

Thus, diaphragmatic breathing would give from 300 to 600 cubic centimetres more than clavicular breathing; and costal respiration, from 100 to 300 cubic centimetres more than abdominal respiration.

I question, not the figures obtained, but the way in which they may have been obtained, because if one could have followed with X-rays the displacement of the thorax and the diaphragm, one would have remarked that in costal breathing, the diaphragm executed ample movements; therefore, in the three cases observed, Dr. *Joal* surmising as much, the patients were making a complete respiration when they were setting into action the lower thoracic wall. In what he calls diaphragmatic breathing, he requested the patient to keep the lower ribs still. Consequently, it would be correct to replace, in his table, thoracic breathing by full breathing. I have received confirmation on the subject by two out of the three patients on whom Dr. *Joal* made his experiences.

I will give further the pneumographic diagram of one of them which confirms my opinion.

I have made great numbers spirometric examinations on several artists, and I give below the results obtained with some of the best known amongst them.

Messrs. *Maurice Renaud* $3^{l},95$; *Alvarez* $4^{l},10$; *Saleza* $5^{l},35$; *Vaguet* $3^{l},90$; *Noté* $4^{l},80$; *Carusa* $4^{l},50$; *Escalaïs* $2^{l},40$; *Courtois* $4^{l},1$; *Frantz* $3^{l},70$; *Guillamat* $3^{l},80$.

Mrs. *Chenal* $3^{l},80$; *Flahaut* $3^{l},65$; *Y. Gall* $3^{l},15$; *Lapeyrette* 3^{l}; *Doménech* 3^{l}; *Berthet* $3^{l},70$; *Hatto* $2^{l},50$; *Borgo* $2^{l},50$; *Grandjean* $2^{l},15$; *Lafarge* $2^{l},10$; *Carrère* 2^{l}; *Mérentié* 2^{l}; *Litvinne* $1^{l},80$; *Nilda* $3^{l},70$; *Cavalieri* 2^{l}; et *d'Aguiar* $4^{l},10$.

Besides these results, I have also examined the spirometer measure of a great number of persons; this has enabled me to observe that in women the average of the pulmanory capacity varied from $1^{l},80$ to $3^{l},80$; and in men, from $2^{l},50$ to 5 litres.

Thoracic perimeter. — Another matter of importance is the knowledge of the thoracic measure, whose variations throw a very useful light on the working of the pulmonary organ.

To take this measurement, use is generally made of a centimetric band graduated from 1 centimetre to 150. If it is possible, it is better to have a metre with a very flat ring at the end, through which can pass the other extremity of the ribbon, as this makes the reading easier.

The patient is asked to stand before the operator, the arms hanging loosely down; then a mark is made at the place through which the metric ribbon will have to pass horizontally. Very often the ribbon is simply placed underneath the arms, in the back, at the end of the lower corner of the shoulder-blade, and in front below the breast. But, as is explained further on, a better way of proceeding is to take several measurements according to parallel planes. One must be careful to always draw the ribbon with even strength, in placing the end of the metre on the median line of the body. A reading of the number of centimetres should be taken after a deep expiration.

If a verification of the development of each side of the thorax is desired, a centimetric ribbon of two halves symmetrically graduated from 1 to 75, and joined by the two figures 1 fastened together is used, and one places it on the axis of the spine (ridge of the thorny apophysis of the vertebrae).

According to *Dally*, the thoracic perimeter ought to be equal to the half of the height plus 2. The people who have not the above perimeter would be apt to become consumptive. I may add that respiratory exercises can restore the normal perimeter.

An individual whose height is 170 centimetres ought to have a chest girth of 170 : 2 = 85 + 2, that is of 87 centimetres at the least.

To find out the variation of the perimeter during the respiration, one begins by taking the measure, as aforesaid, at the end of the expiration; in reading anew the figure marked on the ribbon, one knows how much the thoracic perimeter has increased; thus, one is aware of patient's respiratory course.

The development of the breast, as also of the muscles and of the sub-cutaneous fat tissue, or else the more or less marked prominence of the shoulder-blade's angle, can be causis of error in the measurement of the thoracic perimeter, if the ribbon is placed at the height previously indicated. This measure would be certainly incomplete, because of the changing of position of the chest's different diameters : is not the epigastric hollow the portion offering normally the greater excursion, whilst the point where the excursion would be the feeblest, would correspond, according to *Ackermann*, to the fourth intercostal space?

Considering the unequal dimensions of the different points of the chest, it is necessary to take the measure of the thorax at different height. The thoracic, or thoraco-abdominal perimeter must therefore be measured in the following way :

1° On the level of the arm-pits, underneath the arms, so as to have the measure of the *upper thoracic* or *clavicular respiration.*

2° On the level of the lower end, or point of the sternum, also called xyphoid appendix, to obtain the measure of the *lower thoracic* or *costal respiration.*

3° On the level of the stomach and of the third false rib, in other words, at equal distance between the lower end of the sternum and the navel, so as to get the measure of the *abdominal* or *diaphragmatic respiration.*

4° In certain instances, specially in children, on the level of the navel, so as to know the measure of what we shall call the *abdomino-ombilical breathing*, to distinguish it from the precedent mode of respiration. It is advisable to make several measurements and to average them, for the patient does not always breathe equally and regularly, when he is subjected to these experiences for the first time.

It is easy to translate graphically the results of these different measurements, by drawing horizontal lines which represent respectively the upper thoracic breathing, the lower thoracic breathing, and the abdominal breathing. If the divisions of the metre are marked on these lines, every 5 centimetres for instance, to obtain

the graphic of the respiration it is only necessary to mark on each of them the result obtained by the means of the apparatus which has been used, and to join by a line each of the points marked.

For instance, let us suppose that we have got the following measures : upper thoracic expiration 94 and upper thoracic inspiration 101; lower thoracic expiration 98 and lower inspiration 104; diaphragmatic expiration 97 and diaphragmatic inspiration 103, they would be drawn on the table in the following way :

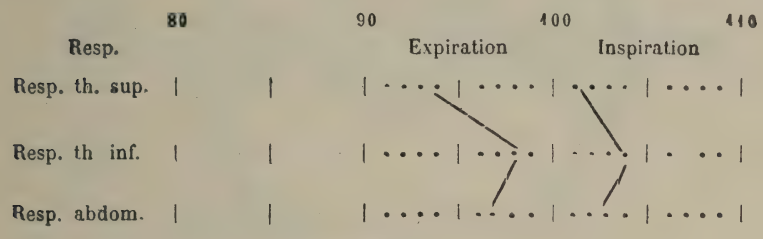


Figure 9.
Respiratory shema, normal type.

The play of the perimeter is normally of 9 to 14 centimetres in adults, and of 6 to 9, in children.

To have a good respiration, it is necessary that the different diameters of the thorax should expand about equally during inspiration, otherwise the breathing is defective; as, for instance, when the perimeter taken on the level of the upper thorax is greater than others, which happens in women who wear stays, or also when the perimeter of the abdominal wall increases abnormally, as is the case for people who lead a sedentary life, by reason of the lack of elasticity of the abdominal wall.

Though generally the centimetric ribbon is sufficient to take the measurements of the various perimeters, trials have been made to obtain more precise results by means of apparatus, like *Fick*'s pneumograph, which is composed of an india-rubber pear pressed around the chest by a waistband. The pear is put in communication with a registering apparatus, or a manometer, which must be very sensitive, so as to indicate the least movements of the thorax.

I will make no mention of a series of other apparatus used only in cases of deformation of the thorax, a matter which concerns the orthopedist.

Registration of the amplitude and duration of the movements of the thorax. — It is of great interest to be able to compare graphs

taken according to the different thoracic and abdominal levels, which have been mentioned above. This registration is made by means of the *pneumograph*.

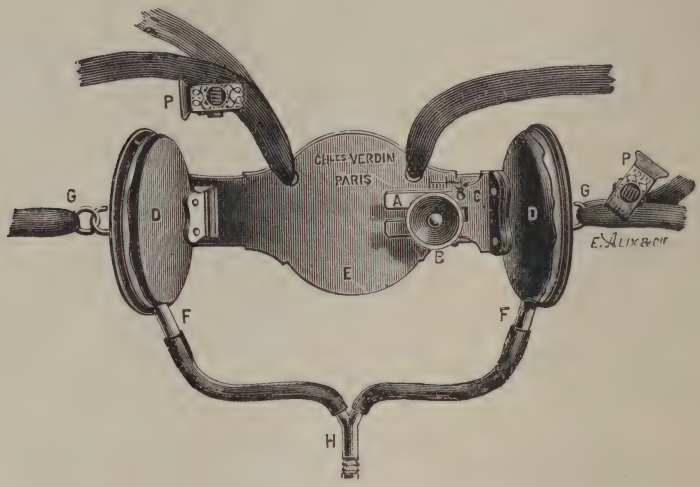


Figure 10.
Verdin's pneumograph.

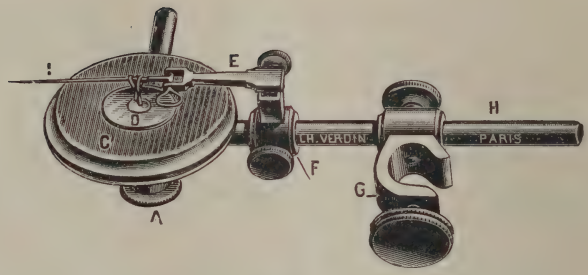


Figure 11.
Lever drum.

One uses generally the *pneumograph with double cup* of *Verdin* (Fig. 10). It is composed of a plate, *E*, at both ends of which are fixed perpendicularly two drums, or cups, *DD*, facing each other by their rigid side; the two extremities, *GG*, of the perithoracic ribbon are attached to the middle of an india-rubber membrane, provided with a hook; this membrane forms the other side of the cup.

The cups communicate with a lever drum by means of an india-rubber tube *H*. This registering drum (Fig. 11) is provided with an india-rubber membrane, on which is stuck an aluminium plate

connected by a fork to a registering lever, *l*, in such a way that all the rising or falling movements of the membrane become translated by the corresponding ascents or descents of the lever.

The registering lever is placed so as to come into contact with a registering apparatus, composed of a metallic cylinder (Fig. 12) which turns on its axle and works with a movement of regular rotation, by means of a watch mechanism. One covers over the cylinder with a sheet of paper blackened with the smoke of a taper. The watch movement carries on the cylinder, thus prepared with a regular and uniform speed which can be regulated at will. The point of the registering lever draws the outline on the blackened sheet by removing the lamp-black.

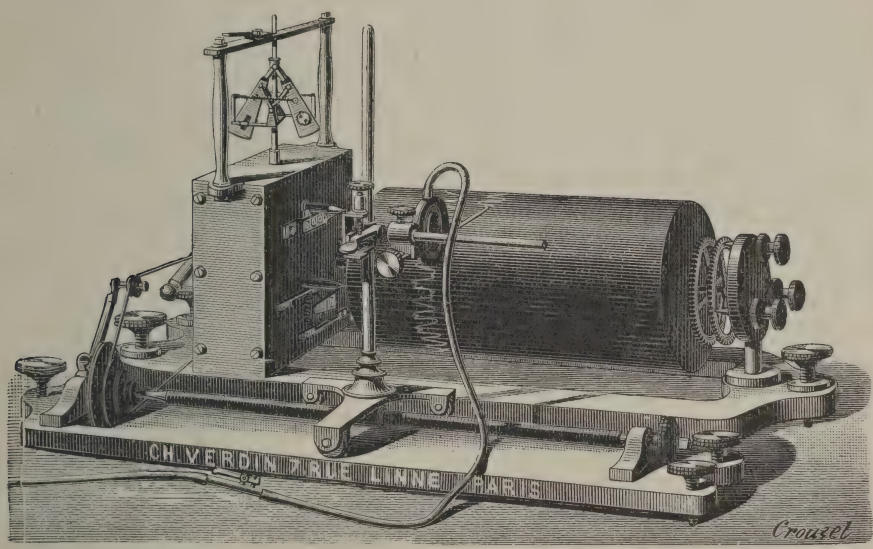


Figure 12.
Registering cylinder with clockwork movement and regulator.

Each time the chest rises, that is when inspiration takes place, the ribbon, fastened onto the hooks of the india-rubber membrane of the double cup, draws the latter outwards, rarefying the air in the air chamber and in the lever drum which, in falling, draws along the registering point.

If the pressure increases inside the cups, that is during expiration, the contrary phenomenon takes place and the drum's lever rises. When the levers are so disposed as to permit the inscription to be made on the registering cylinder, one can see that when the thorax

expands (inspiration) the point traces a descending line, and that expiration is inscribed through the raising again of this line, which offers a curve, nearly vertical in the first part of its course, and rounded at the end of the expiration.

To have an exact notion of the patient's way of breathing, the outlines are taken at different heights. If one uses three pneumographs, the amplitudes inscribed by the first one, placed on the chest at the height of the upper ribs, will be feeble; those of the thoracic region will be wider; and finally, those of the umbilical region will still be somewhat greater, which proves that the maximum breathing movement is effected at the level of the midriff.

In women, the amplitudes inscribed by the upper pneumograph are greater than all the others, consequently to the clavicular mode generally used by the grown up woman who wears stays, which compress the chest and the abdomen. Let it be observed that for some years, at least in France, fashion has done away with the stays which squeezed the thorax, and has replaced them by a belt around the abdomen, which leaves more freedom to the lower ribs.

Lastly, in children, the pneumograph placed on the navel is the one which furnishes the greatest amplitudes.

I am giving here an example of graphs taken from two singers : a tenor (Fig. 13) and a contralto (Fig. 14).

In the first outline, the clavicular breathing is very little developed; contrary to the abdominal breathing which exceeds even the thoracic breathing. This is the type of the thoraco-abdominal respiration.

In the second outline, the graphs show that the singer has a complete respiration, a very rare fact in a woman. Normally the curves ought to run in a parallel direction, and their dissociation must be interpreted as the result of defective breathing, what it does not take place here, but will be examined in due course.

According as one of the outlines shows that the working of one part of the respiratory bellows prevails on the working of the adjoining region, one is able to distinguish the following respiratory modes :

1° the upper thoracic, or upper costal respiration, called also clavicular breathing.

2° the lower thoracic, or lower costal, or again lateral breathing.

3° the abdominal or diaphragmatic breathing.

In clavicular respiration, the midriff does not work, and the abdomen is contracted. The expansion of the chest takes place in its upper parts; the greatest elevation is on the collar-bone and the two first ribs which are attached to the spine and the breast-bone; the shoulder and the head participate too in this movement of the

upper ribs, by pursuance of the muscular ties at the surface of the skull. This respiration is performed in a region which lacks amplitude, as it is at the top of the chest, which is the narrowest part of the lung (Fig. 15, 2).

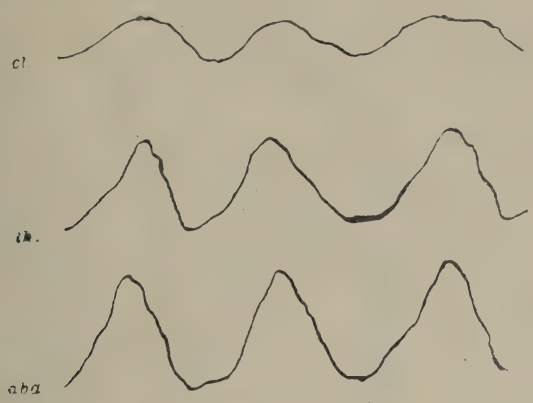


Figure 13.
Pneumographic outline : tenor.

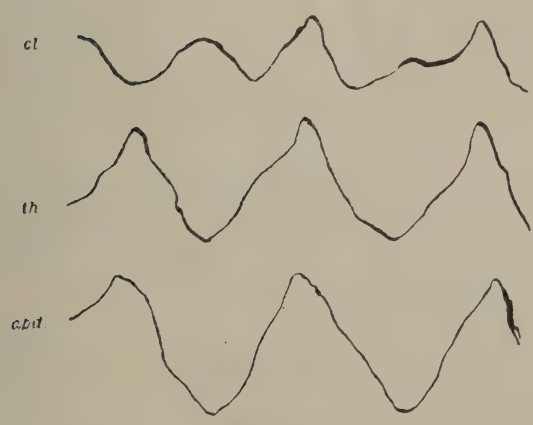


Figure 14.
Pneumographic outline : contralto.

The depression of the stomach's hollow and the raising of the upper part of the chest are indicated on this figure by the line +.+.

In the lateral, or lower costal, or still lower thoracic breathing, the lateral low parts of the chest and the lateral upper parts of the abdomen are set in action. When inspiration takes place, the chest expands, specially in the lateral direction, the midriff hardly works, and the summit of the thorax keeps motionless as do the shoulders;

the abdominal wall is lightly flattened in its two lower thirds. The whole anterior abdominal region, below the under costal line, undergoes a flattening process. The line of inspiration is indicated by the line . — . —

Figure 15.
Diagram of the three breathing types (*Joal*).

1. Side-view of the thorax and the abdomen, before the inspiration ——
2. Clavicular inspiration + . + . +
3. Lower costal inspiration . — . — . —
4. Abdominal inspiration . . .

In the abdominal respiration, the midriff is the principal agent. When inspiration takes place, the midriff, by contracting, flattens and falls at the same time forcing downward and forward the abdominal viscera. This mode of respiration is marked by an inflation of the stomach, indicated by a series of dots (Fig. 15, 4).

In the diagram of the three breathing types, represented on figure 11, one must also take into account that the X-rays have not been used to ascertain the inner working of the organs, in consequence the outlines, showing the movements of the midriff inside the body, cannot be given as correct. Therefore one can only trust the outlines of the body's surface, though it may be stated that this lateral breathing, as aforesaid, is in fact rather a complete respiration.

The use of the pneumograph has allowed *Marey* to observe upon the gymnasts of the « Ecole de Joinville » that the graph showed an important expansion of the breast after a 600 metres race. After a month, the amplitude of the thoracic movements at rest had more than doubled; after five months, it had increased fourfold.

Chassagne and *Dalby* have observed after five months training at the same school, the measurement of the bi-mammary thoracic circumference increased in the case of three quarters of the individuals.

Radioscopy. — Thanks to the discovery of the X-rays, one can easily follow the movements of the thoracic cage and of the midriff, and thus find out in what way the patients breathe.

It has been seen that the thoracic cavity increases through the modifications in curve and lowering of the midriff, and by the raising of the ribs. The midriff presents itself under the shape of a curved line which gives the impression of a dome flattened in its medium part. The curve which limits is lower on the left than on the right, and this difference is more accentuated in the back than in front.

In quiet inspiration, the midriff undergoes a movement of descent of about one and a half centimetres, and in deep inspiration, an average of seven centimetres.

The extremes of the midriff's excursion, in forced expiration, are upwards the sixth rib, and downwards, the eighth or the ninth rib. The lungs adhere to the movements of the cavity which surrounds them.

This method of investigating has enabled us to establish that generally the mode of breathing used by the children, of both sexes, is the abdominal type; by men, the lower thoracic type; and by women the clavicular type.

Besides the thoracic deformations, radioscopy shows us the progressive development of respiration in individuals who are familiar with the exercises of breathing gymnastics. It is also of great use in helping to detect certain defects, like the tremolo for instance.

Normal respiration. — Until the last few years, doctors, professors and artists have laid too great an importance upon the choice of a breathing method.

Some, like *Laget*, and mostly a great number of women, when they were wearing stays, which squeezed their waist, have praised the clavicular breathing, characteristics of which are the raising of the chest's upper part and the depression of the stomach hollow.

Morell-Mackenzie, Saint Yves Bax, Joal, de Reszké... have recommended the lower costal breathing with enlargement of the lower part of the thorax, and flattening of all the abdominal region below the under-costal line.

Lastly, the Drs. *Bérard, Battaille, Longet, Béclard, Küss* and *Duval, Hutchinson, Mandl, Fournié, Gouguenheim* and *Lermoyez* and professors and artists, like *Faure, Giraudet, Lemaire, H. Marchesi*... incline towards the abdominal respiration, with nearly complete immobility of the lower ribs and inflation of the abdomen during inspiration, this inflation being emphasized when the movement of the midriff is more accentuated.

Dr. *Joal*, who believes in the lower costal respiration, has told us that he had examined 62 individuals of whom 11 breathed according to the clavicular type, 19 according to the abdominal type, and 32 according to the costal type.

But, as I have already stated, I am not of the same opinion, for many of the artists who were included above possessed a complete respiration, as I have been able to ascertain.

Dr. *Joal* would be still further greatly surprised in reading *J. Isnardon*'s remark reported in his singing method, and concerning an artist who had been classed among the 32 observers of costal respiration. *Isnardon* writes : « the latter breathed with all the chest » and he adds : « that is how doctors establish statistics sometimes, that is how this excellent Dr. *Joal* has gathered one more testimony for his book which is already crammed with them.

The same remark would certainly apply also to the singing-masters, for, according to *Auguste Laget*, of the « Conservatoire de Toulouse », who recommended the upper costal respiration, *Levasseur, Duprez, Roger* and *Ponchard*, the elder, breathed in the above way. This is not correct, if one listens to *Delprat* to whom *Ponchard* has indicated the diaphragmatic mode he himself practised. *Laget* has also stated that *Garat, Lays, Derivis*, the elder, *Elleviou* and *Martin* had an upper costal respiration. Now these artists have never been heard by anabody of our times, except by *Ponchard*, the elder, who asserted that they did not use this method of breathing attributed to them by *Laget*.

Does it not happen also that at certain moments one of the breathing types seem to prevail over the others, specially when attention is carried that way? It is therefore not surprising to see observers arriving at different conclusion in examining the same individual : this is the case of *Rubini*, for instance. According to *Masini*, the above mentioned tenor is the promoter of the abdominal respiration, while *Bonheur* states that he enlarges the upper part of the chest, and *Walshe* says that he has broken his collar-bone by making a violent effort to deliver a *Si bemol*, into the recitation of *Puccini*'s *Talisman*. Finally, *Lablache* and *Laget* confess that they have not been able to make out on the stage how *Rubini* breathed.

From the above quotations, one can gather that till quite lately, the singers were advised to breathe according to one respiratory

method in preference to any other, but were never told to make use of the complete play of the lungs.

If some professors neglected this question entirely, others, on the contrary, gave it so great an importance, that the student paid more attention to the movements which had to be done by his midriff and abdomen, or by his ribs and stomach hollow, or else by his collar-bones and shoulders, than to the way of producing and holding the tone according to the proper rules. Consequently the result was often disastrous.

Crivelli writes : « Very few singers know how to make a good use of respiration, and often when they try to sing with feeling, succeed only in uttering sounds desagreable to the ear, and in appearing ridiculous by doing all kinds of contorsions. » And the author expressed a doubt as to the reason of this fact, wondering if it was due to inexperience in the teachers, or to neglect on the part of the students.

It is well known that the most of the Italian singers have a greater respiration than their French colleagues; as the latter breathe much more frequently, they are unable to keep the note in the Italian way which appeals so much to the bulk of the public.

In France, the question of breathing has been far too neglected, in spite of the counsels given by *Lablache* and *Manuel Garcia,* who were aware of its importance. Very often one has been contented simply with the ordinary respiration which brings into the lung half only a litre of air, instead of at least three litres.

This is the reason why we see frequently some artists obliged to take numerous inspirations, thus catching the attention of the public who notices perfectly well that it is out of necessity that the singer breathes in that way.

As has been indicated by *Lablache* and *Garcia,* to obtain a good respiration one must take a slow inspiration (let me add : through the nose) and keep the air one moment in the chest, then expire a little more rapidly. In fact, one must bring into the lung a great quantity of air, by means of a long inspiration obtained by a complete respiration, the result of the increase of all the diameters of the thorax; in this manner, the maximum of air which can pass through the lungs is reached.

One can vary this exercise by letting the lung empty itself as slowly as possible, or by taking a quick inspiration.

Certain persons advise emptying the lungs before the flame of a candle which must not flicker when the breath comes out softly; others have made similar use of a glass tube. But these contrivances are only variations of the above exercise.

It is necessary to have recourse to a series of exercises which constitute the respiratory gymnastics, if one wants to increase the

volume of air passing through the air passages, and thus render the respiration larger, the exchanges of gas more complete, the circulation more active, at the same time as one develops the power of work and resistance to fatigue, and regulates the supply of air, by varying the time of inspiration and respiration.

I have already mentioned that men breathed generally according to the diaphragmatical respiratory method (as children do) or else the lower costal type, because the weight and shape of their looseley belted clothes, and the use of braces, whilst, on the contrary, women used the upper costal mode, as they wore stays which prevented the lower ribs from moving, and compressed the abdomen, impeding the normal motion of the midriff.

The object of respiratory gymnastics is to fight these bad dispositions and give back to the patient the complete breathing, that is the expansion of the thorax by the inspiratory muscles and by the normal working of the midriff.

Let me insist on the play of this muscle : according as it takes its prop on the lower ribs, by its central part, or on the adbominal viscera, the diameters of the thoracic cage increase in height or in width.

In the first case, when the diaphragm takes its prop on the ribs, its central part, which is movable, in contracting, drives back the viscera which fall, so that the vertical diameter of the thoracic cage is enlarged by the moving of the muscle.

On the contrary, if the viscera are motionless, the midriff, when it contracts, supports itself on the central part which covers over the visceral mass, and has its movable point on the lower ribs which it raises, dilating the chest by its antero-posterior and transversal diameters. It is this result one must endeavour to obtain by securing an abdominal prop to the midriff, and by maintaining the visceral mass in a receptacle whose walls are firm, thanks to the contraction of the abdominal muscles.

The progressive steps in breathing are rapid, specially in children; as soon as they have understood what they have to do to breath thoroughly, the thoracic course increases quickly by several centimetres.

To these breathing exercises ought to be added singing and blowing exercises, like holding the tone as long as possible, and blowing out a candle at a distance which is increased gradually.

If the exercises must be properly executed, care must be taken that the patient is not in a tired condition; also they must not be pursued until weariness occurs.

The best conditions for practising these exercises, is to make them in the open, or at least in front of an open window, and when

the stomach is empty; one ought therefore to begin them before breakfasting, or else at least two hours after the meals.

It is necessary to wear a garment which does not embarass the movements, which is neither too narrow, nor thick, nor adhering to the skin; a thin woollen blouse would be suitable, or better still a woollen jersey worn directly on the skin, without any other clothes.

It may be observed that the person who is asked for the first time to take a deep inspiration, always, or nearly always, opens the mouth and makes an abrupt movement to raise the thoracic cage, but without however expanding it, then lets it fall back to its original position by sheer elasticity of the muscles, so that no extra quantity of air has been sent in the lungs. Quite different is the result if one is careful to take a deep and abundant inspiration, for the lung is thus far better aired than when several consecutive inspirations of lesser volume are taken.

The breather must inhale through the nose, with mouth shut. Though certain authors recommend expiration through the mouth, it is advisable to expire by the nose.

(A new-born baby does not know how to breathe otherwise than through the nose. If one shuts its nostrils, one must depress its tongue to force it to breathe through the buccal-passage.)

However, if the mouth has tendency for keeping open, a medical examination of the upper passages is necessary in order to remove the obstacle.

I shall now describe the principal exercises which I recommend.

First exercise. — *Diaphragmatical breathing in dorsal decubitus.*

The subject lies down on the back, on a bed or on a table, hands resting flat along the body, or better still : joined under the neck; a small cushion or a pillow placed between the shoulders.

A slow inspiration is then taken through the nose, and at the end of the inspiration the breath is held for a few seconds, then expired more rapidly, but without producing any noise.

This exercise enlarges at first the lower and medium parts of the chest, and raises and inflates the upper part at the end of the inspiration only. It is highly recommended for women whose breathing is defective through wearing stays. They are thus able to judge by themselves how different is this mode of breathing with and without corsets.

This exercise, as also those which follow, must be executed about fifteen times a minute, and to begin with ought to be practised during a minute morning and evening, at the utmost for five minutes twice a day. The patient must endeavour to obtain regularity and rythm in the respiratory movements. In the beginning a satisfactory

way of proceeding for some persons, is to beat the time with the hand : when the hand goes up, inspiration takes place, and when it goes down, expiration.

If the abdominal movements proceed defectively, it is advisable that the person who superintends the breathing gymnastics, should exercise a slight pressure on the lower part of the abdomen, while the breather inflates the chest slowly and deeply, and should diminish this pressure by degrees during the expiration.

Second exercise. — *Costal breathing. Standing position.*

The breather stands motionless, with feet at right angles, heels joined, legs stretched, stomach drawn in, chest bulged, shoulders pulled backward, head held high, chin drawn in, gaze fixed straight ahead, arms hanging down the body, the palm of the hands against the outerside of the thighs. (Fig. 16.)

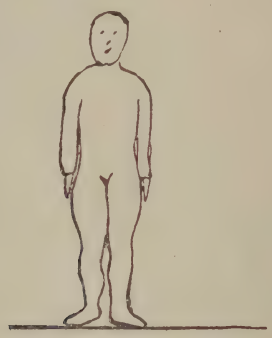


Figure 16.

With the mouth closed a slow and deep inspiration is taken through the nose, so as to bring as much air as possible into the lung. Hold the breath for a few seconds, then drive the air out of the chest, softly and noiselessly with a speed which hardly exceeds the one of normal expiration.

This exercise must be repeated five or six times, and followed by a few minutes rest. Four series of these exercises ought to be done daily in one or two sittings, each sitting never including more than five minutes work.

Third exercise. — *Raising on the tip of toes and heels.*

The position is the same than in the previous exercise.

During inspiration, raise slowly on tiptoe, keep this position for about two seconds, then come back to the normal position, expiring suddenly but noiselessly. Repeat this exercise, but in carrying

this time the weight of the body on the heels, the toes being lifted upward during the inspiration; then expire in coming back to the original position.

This exercise develops the coving of the breast.

Fourth exercise. — *Upper costal breathing. Elevation of the arms.* The position is the same as in the second exercise (Fig. 17, *A*).

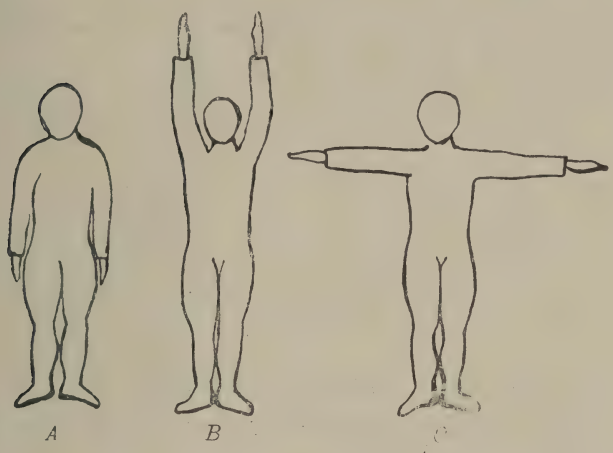


Figure 17.

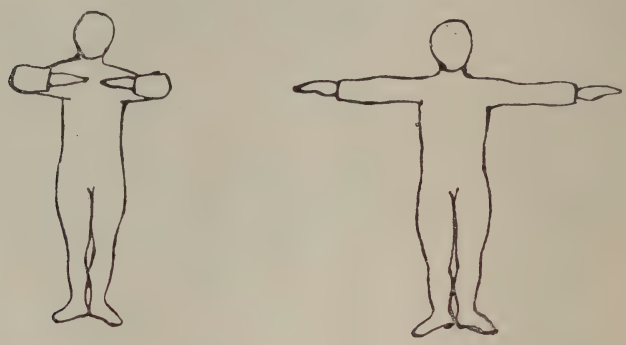
During the inspiration, bring the arms forward without bending them, the hands being opened with palms turned outwards, then raise them vertically above the head (Fig. 17, *B*). In this exercise, the upper limbs move according to a vertical plane parallel with the body's antero-posterior median plane.

Whilst the subject holds the breath, the arms leave the vertical position so as to move, according to a plane perpendicular to the first one, and are lowered laterally, until they reach the level of the shoulders; they are thus in the form of a cross (Fig. 17, *C*). Then one brings them back to their first position, meanwhile expiring vigorously.

Fifth exercise. — *Lateral and horizontal extension of the arms.* The same position as for exercise *A* (Fig. 17).

Place the arms on the level of the shoulders, the fore-arms being bent forwards and inwards, the elbows drawn backward, the hands following the direction of the fore-arm, the fingers clasped together, the palms turned towards the ground (Fig. 18, *A*). During the inspiration, stretch out the fore-arms, without moving the latter.

The arms are in the form of a cross, but the palms of the hands are turned down (Fig. 18, *B*). During the expiration, the fore-arms come back to their original position of flection, and the hands are placed again in front of the collar-bones. The whole movement works according to an horizontal plane.

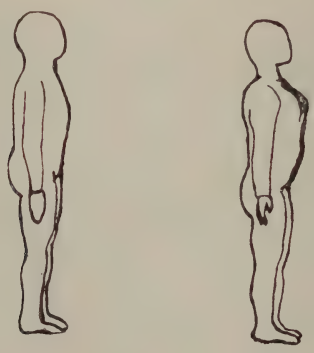


A *B*

Figure 18.

Sixth exercise. — *Rotation of the shoulder.*

Vertical position. The palms of the hands are turned against the outer side of the thigh.



A *B*

Figure 19.

During the expiration, execute the rotation from the back of the shoulder articulation (scapulo-humeral articulation), in other words turn the arm outwards, so that the palm, which originally was placed towards the external face of the thigh (Fig. 19, *A*) be directed forward (Fig. 19, *B*). Care must be taken during this movement to project

the chest forward and upward. The air is held as long as possible, while this position is kept, then it is expired during the rotation of the arm inward.

Seventh exercise. — *Swimming out of water.*

Place the arms as for swimming (Fig. 20, *A*), that is stretch them forwards, the palms touching each other, then draw in the breath while spreading the arms slowly out in the form of a cross (Fig. 20, *B*) and throwing forward the trunk. Keep this position a few seconds and hold during that time the air in the lung; then bring back the arms more swiftly along the body during expiration.

To render the backward movement of the arms easier, it is best to raise on tiptoe during inspiration and to lower the heels during expiration.

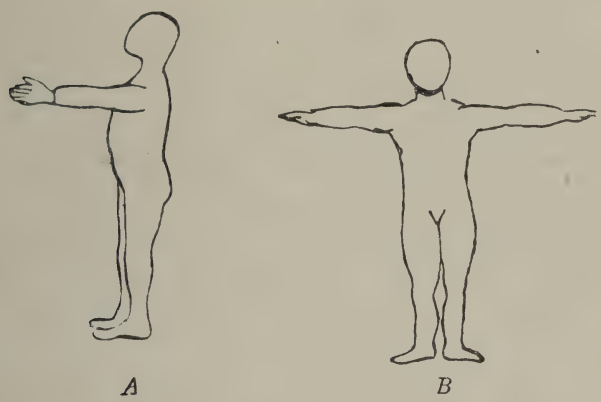


Figure 20.

Eighth exercise. — *Flexion of the trunk, forward, backward and sideways.*

Vertical position, hands on the hips, palms backward.

Take a deep inspiration at the same time as you bend the thorax forward and downward and lift up the head (this is easily done if you take the precaution of fixing a determined point); the legs must be well stretched (Fig. 21, *A*). Stay a few seconds in this position, keeping the air in the lung, then come back to the original position during the expiration which must be more rapid than the inspiration.

To execute the flexion of the trunk backwards, the same position is taken as previously, the trunk is thrown back during the inspiration (Fig. 21, *B*). This position is kept for a few instants whilst holding the breath, finally the first position is resumed expiring radiply at the same time.

To make the movements of lateral flexion, one places oneself as previously, with legs stretched apart. During the inspiration, bend the trunk to the right, without bringing neither right hip nor shoulder forward (Fig. 21, *C*). Hold the breath before letting it escape rather suddenly while resuming the vertical position.

A *B* *C*

Figure 21.

The movement is the same for the flexion to the left.

Ninth exercise. — *Torsion of the trunk.*

Stand erect, legs apart, hands on the hips, elbows backward. While the lower part of the body stays motionless, turn the head to the right, at the same time executing with the thoracic cage a movement of rotation, equally to the right.

Figure 22.

The same movement is repeated on the left.

One must be careful to keep the pelvis perfectly motionless during these exercises.

The eighth and ninth exercises are intended to render the spine supple. The following exercises serve the purpose of restoring the

tonicity of the abdominal muscles by means of their contractions. These muscles fight efficaciously the stagnation of the blood in the abdominal viscere. Further more in individuals who lead an indoor life, or who have a too abundant nutrition compared to the daily maintainance ration, also in many women owing to the wearing of stays, the abdominal muscles (major straight muscles, minor straight muscles, etc.) which form the physiological abdominal band are relaxed or emaciated. It is therefore necessary to train them daily, so as to bring them back gradually to their normal development and to restore this band, which some artists artificially replace by the means of an elastic belt, without which they cannot sing.

Tenth exercise. — *Dorsal decubitus. Contraction of the abdominal muscles.*

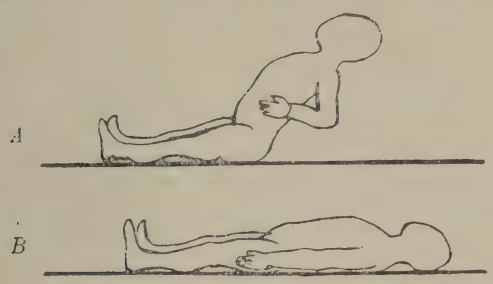


Figure 23.

Dorsal decubitus, or position of the body lying on the back. Flexion of the trunk on the thighs.

The subject lies on the back, in preference on a narrow table, the head in extension, the chest depressed, the abdomen at rest, the hands on the hips, the lower limbs stretched out, the feet placed under a piece of furniture, or held down by the hands of an assistant, or else fastened to the table or the bench being used for the exercise (Fig. 23, *B*).

During the inspiration endeavour to sit up (Fig. 23, *A*) without help of the hands which can be stretched out in the form of a cross. During the expiration, the thorax is brought back to the dorsal decubitus.

Eleventh exercise. — *Dorsal decubitus. Flexion of the lower limbs on the trunk.*

The position is the same as in the previous exercise (Fig. 24, *A*)

During inspiration, raise successively the outstretched right leg, then the left, and finally both together (Fig. 24, *B*). During expiration, lower the legs very slowly so as to make them resume the original position.

Twelfth exercise. — *Joint exercises of the upper and lower limbs.*

The movements of the upper and lower limbs can be combined by placing the arms vertically in the air, while one is lying on a table.

During inspiration, the arms should be stretched laterally in the form of a cross, and the outstretched leg should be raised. During expiration, bring back the arms in front of the body, at the same time lowering slowly the leg.

Each of these exercises must be done at first separately, and repeated five or six times at the utmost, then later be practised with others, but so that the whole sitting does no exceed five minutes in the beginning; at any time it must never last more than ten minutes. These exercises can be repeated morning and evening. After some time, it is advisable that singers should replace the expiration of

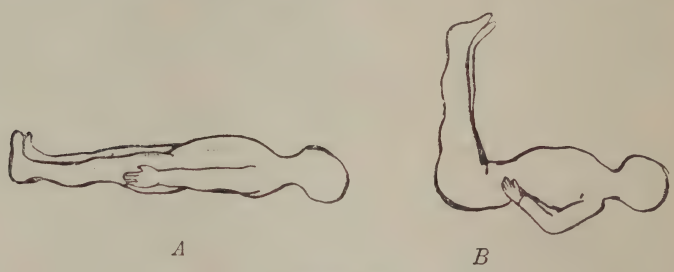


Figure 24.

breath by the emission of the letter *a*, held during the whole expiration; then instead of one letter, they should utter the syllables *ba, be, bi, bo, bu, da, de, di...* One can also count in loud and distinct voice, till the breath goes out, and later pronounce a whole phrase.

Respiratory gymnastics are not only of great use in the emission of the voice[1], but also in a certain number of pathological cases. Consequently it is necessary to have recourse to them in the case of children who have been operated for adenoids growths or for enlargement of the tonsils, for as they have lost the habit of breathing through the nose, their respiration is only superficial.

These exercises must also be practised in cases of thoracic insufficiency, either with or without deviation of the spine, in passive

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[1] Some singing-masters, like *Lablache* and *Manuel Garcia*, for instance, to endow their pupils with a good respiration by way of exercise, have told them to inspire slowly a great amount of air, without singing, and to hold it one moment, then to let it go out as slowly as possible, and finally to keep the lungs entirely empty for a few seconds. Others, as *Panofka, Lemaire* and *Lavoix*, the younger, wrongly believed that this exercise tired the lungs, without proferring any benefit to the singer.

congestions of the lung, in asthma, emphysema, chronic bronchitis and tuberculosis; they are highly recommended to women who have a predisposition for catching the latter disease. Breathing gymnastics are also efficacious to fight stammering, spasmodic contractions, stage-fright, etc...

I will not insist further on the importance of respiratory gymnastics by means of which the perimeter and the faculty of enlargement of the thorax, as well as the vital capacity of the lungs, are rapidly increased. It is easy to ascertain that the quantity of air which constitutes the vital capacity passes from 500 cubic centimetres (current air) to more than 3 litres and even 4 litres, in individuals who practise the exercises a few minutes daily.

The consequences of a bad respiration will be examined in due course.

CHAPTER II.

FORMATION OF THE SOUND.

Theory of the formation of sound. — There are a great number of theories concerning the formation of sound.

Aristotle localized the generation of voice in the larynx and, at the instance of *Hippocrates*, ascribed the articulation of speech to the tongue.

A century before Christ, *Vitruvius* believed that voice was a breath which, when it escaped, set the air in vibration and became sensible to the ear.

According to *Galien*, the lips of the glottis must approximate so that the sound should be produced; the lung acts as bellows, and the mouth raises the sound.

Dodart thinks that the vibrations of sound are due to the grazing of the air which escapes violently from between the two lips of the vocal ligaments, these being stretched accordingly.

Forty years later, in 1741, by putting into contact the lips of the glottis of a dog whose larynx had been taken away, and by blowing vigourously in the wind-pipe, *Ferrein* succeeded in producing a loud sound; he therefore concluded that the vocal cords determined vibrations.

In 1839, *Müller* looked upon the larynx as a rud with two membranous lips, which could render all the sounds of the musical scale, just like one pipe. According to him, the pitch of the tone depends upon the length of the opening of the glottis, the tension of the cords remaining a constant; when the glottis widens the tone is deeper, when it narrows the tone is higher.

The larynx has been compared by authors in turn to a musical instrument : by *Galien* to a flute, by *Magendie* to a hautboy, by *Despinez* to a trombone, by *Diday* to a hunting horn, by *Savart* to the decoy-bird, by *Biot* to an organ-pipe, by *Malgaigne* to a squeaker, by *Ferrein* to a spinet, by *Descartes* to a whistle, by *Helmholtz* to a rud-pipe, etc.

It is in the larynx, without any mistake, that the tone is produced; in an individual who has been tracheotomized, in other words to whom one has opened the windpipe below the larynx, the voice is abolished; if one obturates this opening so as to restablish the passage of the air through the larynx, the voice reappears.

Until quite lately, most of the authors believed that the sound was formed on the level of the vocal ligaments, without agreeing however on the way the tone was engendered; some like *Savart, Dodart, Helmholtz,* etc... ascribed it to the air vibrations; others, like *Ferrein, Müller, Battaille,* etc... to the vibrations of the cords.

Which of these theories was the correct one? As Dr. *A. Guillemin* judiciously observes, when different answers are given to the same question, it is because every interlocutor is accustomed to judge from his favourite point of view. What is necessary for the making of a good coat? A good tailor says the clothes maker. A good stuff, answers the draper.

However, I will leave aside, for the moment, the original cause of the vocal vibration, and consider instead what are the conditions of voice production according to the actual theories.

To this effect it is necessary :

1° that the air current should have sufficient pressure;

2° that the aperture of the glottis should be shut sufficiently;

3° that the vocal cords be stretched.

If these conditions are not fulfilled the vocal ligaments are not set into vibration, and only whispering is obtained.

1. **Air pressure.** — The air, to be able to set into vibration the vocal ligaments, must undergo, when it passes through the glottis, a pressure sufficient to stretch the vocal ligaments away from their position of equilibrium. This pressure can vary from 50 to 100 millimetres of water [1].

To acquire this pressure indispensable for the production of the sound, the air contained in the air passages must be sufficiently compressed by the action of the chest's expiratory muscles, and must not escape too rapidly outside.

An indrawn air current can also vibrate the glottis and produce the voice; but it is an anormaly, because to give birth to tone under

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[1] According to *Valentin,* the stength of the expired air current balances mercury column of 4 to 5 millimetres of a water column of 60 millimetres, and energetic respiration counterpoises a mercury column of 10 millimetres, or a water column of 140. *Cagniard-Latour* has found that in singing in a moderate tone the pressure was of 160 millim. of water; in a highter tone, with the same voice power, the pressure was of 200 millim. of water; and in a loud call, the pressure reached 945 millim. of water. According to *Waldenburg,* the expiratory pressure in men is 100 to 130 millim., and in women 70 till 110 millim.

these conditions, one is obliged to make very great efforts so as to bring on the glottis the pressure necessary to set it into vibration. Therefore one determines a fatigue of the phonation apparatus by subjecting it to this overwork.

2. **Occlusion of the glottis.** — Voice is not possible when the vocal ligaments are stretched apart, at least only a few dull notes can be uttered and in a very deep tone.

The diameter must not exceed a certain limit which *Kock* values at 2 millimetres to the utmost. Above $2^{mm},5$ the production of voice ceases.

If the closure of the glottis is too complete, as when an effort is made, the air is prevented from coming out, consequently the setting into vibration of the vocal bands is abolished. Contrariwise, if the glottis is too wide, there is aphony, for the air is unable to acquire the necessary tension so as to set the cords in motion; it escapes without vibrating them.

The occlusion of the glottis is produced by the contraction of the arytenoid muscles, which draw together suddenly the arytenoid cartilages, and keep them closely joined throughout the whole height of their inner side. The lateral crico-arytenoid muscles work to the same effect by approximating little by little the arytenoidei and, consequently the vocal cords, and reducing progressively, according to the needs of the voice, the glottic area.

3. **Tension of the vocal cords.** — The vocal cords must not only be drawn together, they must also be stretched. *Ferrein*, and more specially *J. Müller* have studied this question of tension.

The tension of the vocal cords can be produced in two ways :

1° by means of a traction exercised according to the length of the ligaments (active tension of the vocal cords).

2° by means of an extension, in a direction perpendicular to this axle by the action of the expired air current (passive tension of the vocal cords).

To make his experiments, *Müller*, like *Cagniard de Latour* and *Malgaigne*, has made use of a membranous rud composed of two elastic bands stretched on the extremity of a tube, and between which was left a small chink representing the glottis. The air which is pushed inside the tube escapes through this chink, thereby vibrating the cords.

He also pursued his researches upon dead larynxes, putting the glottis back in place, and fastening onto the thyroid cartilage a band provided with a small scale, which was meant to receive the weights indicating the degrees of tension of the cords according to the different sounds produced.

By gradually increasing the weights which stretched the vocal cords, from 7 grammes up to 540 grammes and even 960 grammes [1], he managed to obtain sounds rising from *La* ♯ [2] (about 226 simple vibrations per second) to *Ré* ♯ [5] (1223 s. vib.).

Müller, with the same blowing force succeeded in going over an interval of more than three octaves by varying only the tension of the cords. He remarked furthermore that very short vocal cords can render deep tones, as long as they are completely slackened, and long cords, high tones, if they are strongly stretched.

The second mode of tension of the vocal cords is due to expired air current.

Catching hold of the vocal cords from bottom to top, the air current pushes them upward; the cord is lengthened, extended and stretched.

The stronger the air current, the more pronounced is the curve, and the greater too is the tension which results therefrom; and the greater the tension, the higher the tone.

Before *Müller*, *Lehfeldt* and *Liscovius* had observed that by increasing the air current one could raise the tone to the extent of a fifth, the tension of the cords being kept unaltered.

Müller has been able to raise from between 6 to 9 intervals in tones and half-tones the sound produced at each degree of tension by a gentle current; but this forced sound did not possess the pure timbre of the sound of equal pitch obtained by means of the direct tension of the cords.

The augmentation of pressure of the expired air determines also an increase of intensity, with the result that the vibrations become at the same time ampler and more numerous. The note is higher and louder and, as the glottis widens as the pressure increases, the expired air comes out more rapidly; this accounts for the fact considering the pitch be the same, the softer the tone produced the longer can it be held.

The modification of the sound through the change of pressure of the expired air takes place more easily in the deep than in the high notes, for the cords being slacker they can be more readily bulged and stretched apart in the first case than in the second, when being more highly strung they present a greater resistance to the action of the air.

The artists know well how to avail themselves of this passive tension of the vocal ligaments by means of the increase of the expired air. When they have reached the utmost limits their voice can attain through the maximum muscular contraction, they alter the expiratory pressure and obtain thus a few notes more.

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[1] 64 loths, after the text of Müller's book. The loth is equal to half an ounce, or 15 grammes.

« This explains why tenors sing with all their force the chest *Ut*^{3} (*C*^{3}) ; their stretchers, by a supreme effort, are perhaps just then contracted so as to give *La*^{3} (*A*^{3}) only, but forced expiration increases the tension of the cords by two tones and brings them to the degree desired by he artist. When the note is no longer sung loudly it falls immediately. For the same reason, in the lower passages of their parts, the deep basses utter sounds which are so feeble that sometimes they can hardly be heard. » (*Lermoyez*).

This influence of the force of the breath renders very difficult also the transition from *piano* to *forte* on the same note.

To prevent the voice from coming out of tune, another factor must intervene which keeps the tone at the requisite pitch : that is *vocal compensation.*

Vocal compensation. — It is *Müller* who has given the name of *vocal compensation* to the mechanism which allows the voice to modify its intensity without raising or diminishing its pitch.

We have just seen that the pitch or the height of a tone depends first of all on the direct tension of the cords, and that, considering a given tension, a light air current determines a deeper tone, and a vigorous air current a higher one. Therefore, if one wants to utter a *forte sound,* one must render the expired air current stronger, and, reciprocally, one must make it feebler to pass from *forte* to *piano;* but therefrom results that the tone rises in *crescendo,* and goes down in *decrescendo.* It is why it is necessary in passing on a same time from *piano* to *forte,* and conversily from *forte* to *piano,* that some element should compensate these variations in the strength of the expired air, by relaxing the cords when the voice is increased to *forte,* and by stretching them when the sound passes to *piano.* These modifications of tension, which are meant to counterbalance the fault caused by the variations in the energy of the sound, are obtained either by means of an equilibrium which establishes itself between the passive and the active tension of the cords, thanks to the muscles which diminish the tension, and thanks also to the contraction of the stretcher or to the slackening of the relaxer (a fact which is yet far from being proved) or again by a change in the chink of the glottis, as maintained by *Diday* and *Petrequin,* for instance.

When expiration becomes more energetic, the glottis widens to the effect of leaving an easier passage to the sound; later, if the contraction of the expiratory muscles weakens, the glottis narrows up again so as to oppose a greater obstacle to the pressure of the air current.

The cords lengthen consequently to the dilatation of the glottis, therefore if the muscular contraction does not change, they are more

highly strung by reason of the air pressure, and the sound must go up. (*Lermoyez.*)

I, for my part, do not share this theory, as I have never observed these changes of the glottic aperture, in the majority of singers whose larynx I have examined.

According to *Haller*, during the generation of the series of vocal sounds, the glottis must work independently from the variation and speed of the air current. It must be able to produce deep tones under a strong pressure, and shrill tones under a week pressure.

Stephen de la Madelaine had been struck by the same thought. This artist expresses himself as follows concerning the increase of force in the impulsion of the air current : « I am mentioning this last condition out of respect for science to which however humble practice at times rudely gives the lie, and specially in the present circumstance. »

With the help of the theory I am exposing further on, vocal compensation is easily explained without any intervention of other agents meant to counterbalance the variation of tension due to the traction of the cords and to the expired air current.

We are aware of the conditions which are believed to be necessary for the formation of the sound; we must now consider what takes place in the larynx when the tone is produced.

Emission of the sound. — The glottis which was widely opened, so as to facilitate the act of respiration, shuts itself up almost entirely under the action of the constrictor muscles. The pyramids come closely together, by means of their posterior borders, the vocal cords are put into contact by their free edges, at the same time as they stretch and as the thyro-arytenoid muscles contract and thicken. The larynx is thus in the proper position corresponding to the tone which one wishes to deliver.

During the production of tone, the vocal cords are drawn suddenly away from each other, and enter into vibration under the influence of the expired air current, which passes through the glottis before proceeding to the upper-glottic regions, so as to enrich the timbre of the voice.

These vibrations are easily observed with the laryngoscope [1], specially in the production of deep notes. One can thus see that the vocal cord is pushed up by the initial air current, then when the elasticity of the cord counterpoises the pressure of the expired air it comes down, but goes beyond its equilibrium position before

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[1] Laryngoscope. — This instrument is a simple plane mirror of the size of a franc, and fixed on a stem (Fig. 25). It is placed in the back of the

being pushed back again by the expired air; in this manner the cord executes a series of to and fro movements, of vibrations varying in number and amplitude, and these movements produce rapid and periodical shocks of the expired air on the level of the glottis.

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throat, on the level of the uvula which is pressed back. In throwing a strong light on the mirror, the image of the larynx is reflected towards the observer.

Figure 25.
Laryngoscopical mirror.

With some practice one can easily enough see the vocal cords which, placed according to an horizontal plane from front to rear, are stretched apart during the respiration (Fig. 26). They offer the appearance of a triangle whose summit is directed upward in the mirror, and whose base, corresponding to the arytenoids, is situated in the back and the bottom.

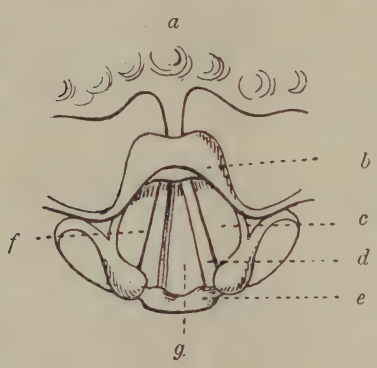

Figure 26.
Laryngeal image in breathing.
The cords are apart.

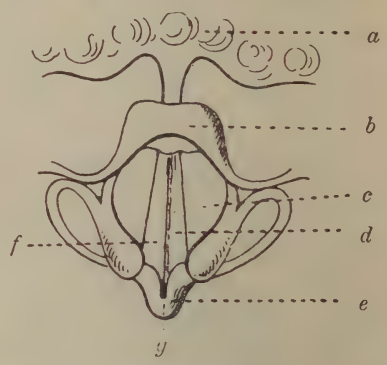

Figure 27.
Laryngeal image in phonation.
The cords are close together.

a basis of the tongue,
b epiglottis,
c ventricular band,
d vocal cord,
e arytenoid cartilage.
f entrance of the ventricle of *Morgagni*,
g glottis.

At the time of the production of tone, the cords come near each other, causing the base of the triangle to disappear. (Fig. 27).

With an improved apparatus, the pharyngoscope of *Hays* (Fig. 28) which is composed of a tube bearing a prism, *C*, and lighted by means of two small electric lamps, *A*, one sees the larynx under different conditions as the patient can shut his lips, the image appearing at the widened extremity of the tube, *C*, outside the mouth.

Varying forms of the glottis in the different registers. — When one goes through the numerous explanations given by authors, as to the way the glottis and the vocal ligaments act in the production of tone, one is struck by the differences of opinion.

Let us examine first the position which, according to the current opinions, would be taken by the glottis in the different voice registers.

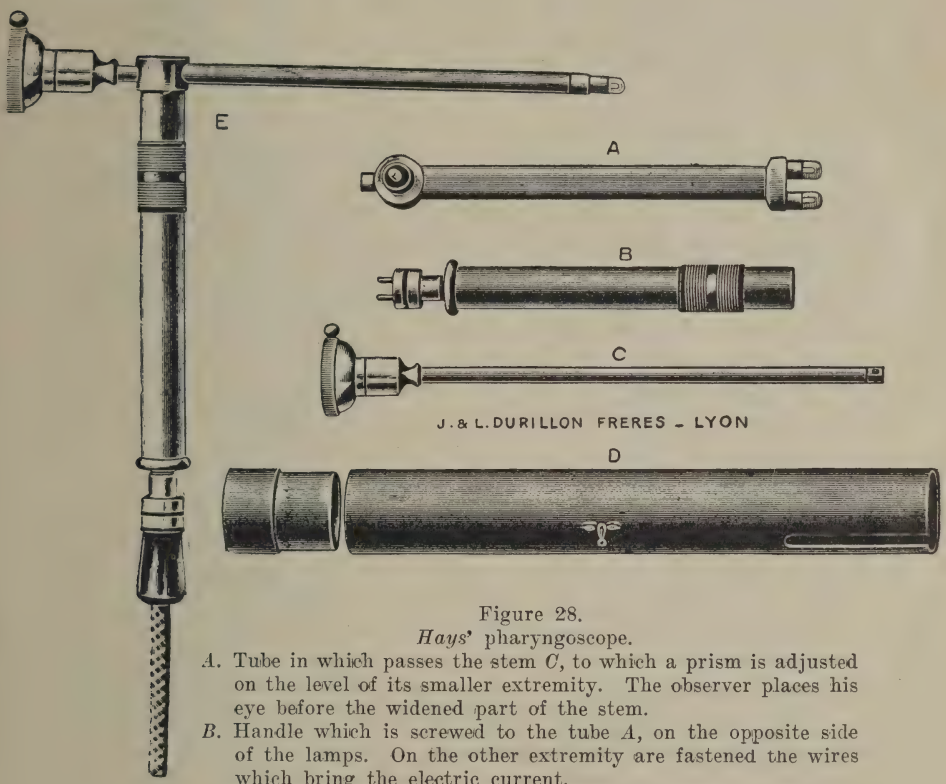

Figure 28.
Hays' pharyngoscope.

A. Tube in which passes the stem *C*, to which a prism is adjusted on the level of its smaller extremity. The observer places his eye before the widened part of the stem.
B. Handle which is screwed to the tube *A*, on the opposite side of the lamps. On the other extremity are fastened the wires which bring the electric current.
C. Tube bearing the prism which reflects the image of the vocal cords towards the widened part, provided with a lens.
D. Box containing the apparatus.
E. Apparatus ready to work.

In the lower register, or chest register, the glottis is opened in all its length (*French*, Fig. 29), the cartilaginous glottis, included between the arytenoids, is closed (*Battaille*, Fig. 30), opened (*Mandl*); the ligamentous glottis, contained between the vocal bands, is opened according to an ellipsoid, and also the cartilaginous glottis which, apparently, takes the shape of a triangle with summit directed towards the front (Fig. 31), thereby producing a narrowing of the

glottis where the cartilaginous and ligamentous parts join (*Lennox-Browne*); the glottis is opened in all its length with an ellipsoidal posterior aperture in the deeper tones (*Mandl*).

Figure 29.
Glottis opened in all its extent.

Figure 30.
Glottis opened in its interligamentous portion.

If the majority of authors seem to agree in admitting that the cords approximate and that the glottis narrows up and becomes linear (Fig. 32) in the ascending scale, it must be owned that the opinions

Figure 31.
Glottis showing a triangular shape in its interligamentous part.

Figure 32.
Linear glottis.

are again at variance in the matter of the upper register, or head register. Here the glottis is reduced in all its length to a narrow line, or shut either from its front side, either from the back, or again

Figure 33.
Ellipsoid glottis.

Figure 34.
Anteriorly ellipsoid glottis.

offers in its middle an elliptical slit (Fig. 33); let us remark however that most of the observers admit that the slit occupies the anterior part of the glottis (Fig. 34).

The same disagreement exists as far as the form of the vocal cords is concerned. According to *French*, they are short and large in the low register and lengthen in the ascending scale to shorten again later. According to *Castex*, they are lengthened in the chest register and somewhat shortened in the head register. The opinion of *Gouguenheim* and *Lermoyez* is that they are stretched in the chest voice and relaxed in the head voice.

Considering the differences in the interpretations expressed by the seekers, must one believe that the testimonies given by the laryngoscope are far from being unexceptionable, or that the glottis does not always appear under the same aspect for the same note or the same register?

This last opinion seems to be justified, if one refers to the studies of *Morell-Mackenzie* who has given a list of observations drawn by him from the most celebrated singers of his period, for he has stated that the glottis, either cartilaginous or ligamentous, varied with each singer.

Another of our colleagues, Dr. *French*, of Brooklyn, who has been able to take many photographs of the larynx from a series of artists, has summed up his researches in the following conclusions :

« The larynx can demean itself in a different manner in the different individuals during the production of the same notes or registers.

« The rule (which offers however many exceptions) is that the vocal cords are short and broad, and the ligamentous and cartilaginous parts open during the emission of deep notes; when the voice goes up the scale, the cords lengthen and narrow, and the aperture situated at the back widens, the cartilages of *Santorini* [1] are drawn in front and the lid rises till about *Mi*^{3} (*E*^{3}) (treble clef, first line). The cartilaginous glottis is then closed and the glottic chink becomes narrower and linear, the cartilages of *Santorini* are drawn back and the lid is lowered.

« It is certain that when the cords are shortened during the lower passages of the voice, the cartilaginous portion of the glottis is short, and the ligamentous portion is not habitually modified. However if the cartilaginous glottis is opened, there exists ordinarily no change in the length of the cords.

« In proportion as the voice rises, from the moment of the note of the lower passage, the cords lengthen and become less wide, the hinder part of the glottic chink opens by degrees, the cartilages of *Santorini* are carried forward, and the lid rises to about *Mi*^{4} (*E*^{4}) (treble clef, fourth space-line) where another change takes place.

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[1] The cartilages of *Santorini* are two small cartilages which are placed above the two arytenoids.

« The glottic chink is then reduced to a very narrow line which, in certain individuals, extends on the whole length of the glottis, while in others it is closed either in front or in the back, or else in these two points at the same time.

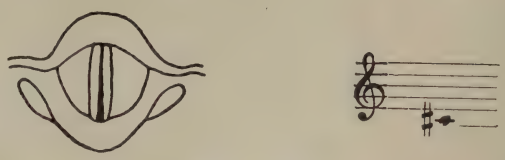

Figure 35.
Glottis in the production of a deep note (*do*♯^{3}) (*C*♯^{3}).
(after *French*).

« The cartilaginous glottis is always closed, but the ligamentous glottis is invariably shortened.

« The pyramids are drawn back and the lid is lowered. While the voice rises in the head register, the dimensions of the laryngeal cavity diminish, the pyramids are carried backward and come closer together, the lid falls and the cords grow smaller in length and breadth.

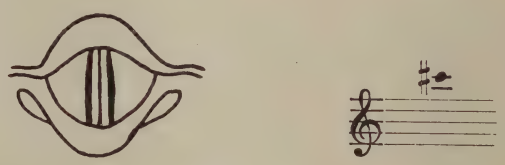

Figure 36.
Glottis in the production of a high note (*do*♯^{5}) (*C*♯^{5}).
(after *French*).

« If the posterior part of the ligamentous glottis is not shut in the lower register (Fig. 35) it is assuredly so in the high notes of the head register (Fig. 36). »

If one looks at the photographs of the singers' larynx published by Dr. *French*, one can see that most of them indicate that the vocal cords are shorter in the emission of deep notes, and longer in the production of shrill notes, the width being however the same, but in the latter case the glottis is narrower.

This can also be verified on the stereoscopic views of the larynx taken by Dr. *Garel*, which show that the vocal cord is larger for the emission of *i* on *La*^{4} note (A^4) than for the utterance of the vowel on *La*^{3} (A^3).

Can one not obtain a pharyngeal voice with the nearly normal qualities of intensity and timbre in laryngectomized individuals who, consequently, have no vocal cords left, but whom has been practised the junction of the wind-pipe with the front part of the neck? This is realized by simply using an apparatus made of a tight elastic membrane, which regulates the speed of the air which comes from the wind-pipe, and brings it into the pharynx through the mouth.

I personally have had the opportunity of examining the larynx of most of the best known artists, and have not been able to observe on them the different aspects of the glottis previously described. I have only remarked that to a deep note corresponded a glottic opening which varied in shape according to each individual, and which allowed the air to pass in greater quantity than for a shrill note, in the emission of which the glottis chink, being narrower, prevents the air from coming as plentifully out of the wind-pipe.

I have also observed that important modifications took place in the laryngeal cavity as well as in the other organs of phonation. *Hays'* apparatus has been most useful to me in my investigations.

It is after having examined these researches, and studied experiences going back as far as *Savart* and Brother *Ch. Lootens*, of *Ghent*, as well as critics and experiences made by Dr. *Auguste Guillemin*, who has specially studied the generation of voice and timbre, that I have come to the conclusion that the vocal cords do not play in the formation of the sound, the principal part which has been attributed to them till now by every author, to the exclusion of the parts of the larynx which should be given the first place as regards the generation of tone (see p. 65).

Vibration of the vocal ligament. — It is generally admitted that the vocal cords, or vocal ligament, by means of their vibrations, are sufficient alone to produce all the tones of human voice. And nevertheless when one takes away the ventricle, the voice is greatly altered.

Whether it is the cord which engenders the vibration and communicates it to the surrounding air or, inversely, the air which vibrates the cord, the necessity of a vibrating solid body has been recognized in the production of tone. And nevertheless, as *Guillemin* has observed, there are many sounds produced without the vibration of a solid body, as in the case of syrens and whistles. Inversely there are bodies which vibrate but do not sound, as the membrane of the phonograph.

A question, interesting to the highest degree, is to know how one can recognize if a solid body contributes to the production of the tone. One has only to touch it, as by doing so one prevents, or at least one impedes, its vibratory movement. It is in that way that one smoothens the sound of a bell. Is this the case for the vibra-

tions of the vocal cord? The experience made by *Liscovius* and reported by *Müller* is conclusive. When he touched the cords with the finger without altering the ampleness of the glottis, the sound did not change, though it ought to have been shriller if the laws on cords applied here. In consequence, the cords do not engender the vibration.

Müller adds that in his experiments on *membranous reeds*, carried out in a similar manner to those he made on vocal cords, the apposition of the finger modified considerably the sound.

« Thus, observes *Guillemin*, *Liscovius*' cords behave otherwise « than *Müller*'s membranous reeds; the latter vibrate and contribute « in producing the tone, the former have only consecutive vibra- « tions, and do not promote the production of sound : they vibrate « because they are surrounded by vibrating air. »

To ascertain the exactness of this opinion, one has only to touch the vocal cords of an anaesthetized individual, as I have often done, with a stylet; one cannot succeed in altering the pitch of the note delivered, thus is confirmed *Liscovius's* observation.

Another proof that *Müller's* theory, which rests upon experiences made on dead larynxes, could not be applied to living larynxes, is that the latter ring an octave or even twelfth lower than the others, but this has not hindered *Müller* from saying that dead larynxes rendered all the tones of human voice, even the deepest notes.

Referring to the same subject, *Longet* has made the remark that the sounds thus obtained gave only a very imperfect impression of the sounds produced during life.

However, the larynxes of the deep basses go down sometimes to Ut^1 (C^1) (65 double vibrations) in chest voice, and ascend with difficulty in falsetto the octave between Ut^3 (C^3) and Ut^4 (C^4). Therefore it is surprising to read in *Müller's* tables that the larynxes of basses, with long cords, give chiefly falsetto notes ranging from Fa^2 (F^2) (174 d. vibr.) to $Ré^5$ (D^5) (1,174 d. vibr.), a note very seldom uttered by a human larynx. As to the chest notes registered by *Müller*, they go down only to Sol^2 (G^2) or $Fa\,\sharp^2$ ($F\,\sharp^2$); on one exceptional occasion a larynx delivered a Si^1 (B^1) (122 d. vibr.), thanks to a process which shortened the glottis and rendered the cords wrinkled and creased.

On the other hand, one is obliged to acknowledge with *Guillemin*, that the cords of dead larynxes are not capable of producing the deep tones which are delivered by living ones, and that the working of these two organs is not alike.

When one examines the tractions employed to produce sounds on dead larynxes, one is surprised to see what considerable forces are used : 64 loths, in other terms about a kilo, to obtain an ascension lesser than two octaves, and practically in falsetto tones only.

Moreover *Müller*, while effecting tractions of about forty grammes in the same direction as the thyro-arytenoidei, was obliged to cease his experiences, for the cartilages were giving way under this slight traction.

On the other side, the tension of the vocal cords is due to the contraction of the muscles crico-thyrodei. Now, the section of the nerve by which it is innervated (external branch of the upper-laryngeal nerve) causes the voice to become hoarse (*Longet*), whilst the voice is abolished by the section of the recurrent, or lower laryngeal nerve which is distributed to the inner muscles of the larynx, and not to the crico-thyroideus : therefore, it is not necessary for phonation to take place for the vocal cords to be strung (*Guillemin*).

As aforesaid, the strong tractions correspond to the high notes. If one wishes to sing these notes softly, the force of the traction cannot be replaced by the passive tension, in other words by the breath power which would oblige these tones to be sung in *forte*. Hence, a soprano would suffer a much greater fatigue by singing *piano* than by singing *forte*, and a bass would have to make no effort in the « voce miste », or mixed voice, and only a very slight one in the extreme notes.

The result would be similar if, instead of the muscular contraction, the pulmonary compression should be called to intervene. In fact, according to *Müller's* experiments, as regards the shrill tones where the tension of the cords is more considerable, the lightest possible breath which can still produce the sound is due to an air pressure « stronger than in deep tones »; when the traction is weak, the pressure varies from four to sixteen centimetres of water if the tone has to be raised a tenth, from Fa^2 (F^2) (in falsetto!) to La^4 (A^4); and when the traction is of 160 grammes to ascend a fourth, from La^4 (A^4) to $Ré^5$ (D^5), the pulmonary pressure exceeds a metre of water.

We may observe with *Gavarret* that the pitches of the tone are not in ratio with the square roots of the tension weights, as required by the laws of physics. They are generally half-a-tone and even a tone below the theoretic indications.

Furthermore, in *Müller*'s experiments, the vocal cords, under the influence of a stretchning weight, undergo necessarily a lengthening which contributes also in lowering the tone and rendering the discord more perceptible.

Besides all the authors are very divided on the subject of the lengthening and the shortening of the vocal cords in high tones, and some of them even, after having defended this hypothesis, end by saying that while the vocal apparatus makes the tone go up and down, the vocal cords do not appear either to shorten or to lengthen. This, I have observed myself.

It seems to me very difficult, when studying the anatomy of the larynx, to admit the explanations which go to prove that, according to the different cases, the cord vibrates wholly or only partially. Already no agreement has been come to by the authors regarding the structure of the vocal cord.

Some, with *Battaille, Rossbach, Henle,* maintain that the muscular fibres of the thyro-arytenoideus penetrate so much forward into the vocal cords, and are so intimately bound to the ligament that one can hardly imagine the latter vibrating alone. *Ludwig, Rühlmann, Michael, Sappey* are of an absolutely contrary opinion. *Sappey,* speaking of the thyro-arytenoideus, says : « These horizontal fibres are those which occupy the thickness of the cords. They form a voluminous fascicule which corresponds on the outside to the lower thyro-arytenoids ligaments. None of the fibres of which it is composed insert themselves thereon, so one can always easily detach it therefrom. » However towards their extremities the fibrous cords receive, on their outer edges, the insertions of some fibres which emanate from the inner borders of the muscles thyro-arytenoidei (*Lermoyez*).

A very uncommun disposition of the thyro-arytenoidei has been observed in individuals who possess an extensive and high chest voice : a certain number of muscular fibres detach themselves from the body of the muscle, according to digitations spread from front to rear, and insert themselves on the vocal ligaments; in contracting these digitations can shorten the length of the cords' vibrating portion, as does the finger pressed on a violin cord. These fibres do not always exist; thus is explained the fact that all men are not tenors (*Gouguenheim* and *Lermoyez*).

The last authors add that the functions of the external portion of the thyro-arytenoidei are badly defined, and however this muscle is « the component part of the vibrating vocal cords. »

As regards the mucous membrane, this is what *Sappey* writes : « When the laryngeal mucous membrane reaches the vestibule of « of the glottis, it adheres by means of a very dense cellular tissue « to the whole expanse of the aryteno-glottic ligaments, and lower « down to the ligaments of the upper vocal cords; then it penetrates « into the ventricle and runs up towards the upper edge of the thyroid « cartilage, amidst a cellulo-adipose mass which surrounds it on all « sides. From the ventricle it passes over the ligaments of the lower « vocal cords, on the level of which it is remarkable by its thinness, « its transparency and the solidity of its adhesion. Lower down, it « corresponds to the perichondrium of the sub-glottic portion, which « is united to it also by a very compact cellular tissue. It therefore « rests in the whole of the laryngeal cavity on fibrous parts, which

« adhere to it so closely that it must be ranged amongst the fibro-« mucous membranes. »

« In the upper direction and on the vocal cords this mucous « membrane is of an extreme thinness, but becomes notably thicker « in the lower regions. It is covered over by a vibratile epithelium; « however on the vocal cords the latter offers the characteristics of « the pavimentous epithelium. »

Contrary to this opinion, Drs. *Martel* and *Lermoyez* maintain that the mucous membrane can be easily detached from the ligamentous cord, and can vibrate independently from the other parts constituting the cord. But many authors do not want to admit that a mucous membrane, which is soft and incapable of contracting, can vibrate to the exclusion of the parts upon which it rests.

We know also that glottis have been described as rectilinear, triangular, elliptical, ovalar, open in front or in the back, or resembling the section of a bi-concave lens; and the vocal cords, as straight, bent, incurved outward or inward, rectilinear in the deep tones and concave in the high ones; and, notwithstanding these various forms, it has been maintained that the curved cords were more stretched, and that rectilinear cords could render deep tones, however strange this may seem, as most of the times the glottis does not alter in shape, and as the cord too keeps an unchanged aspect without lengthening or shortening in the production of tones.

Likewise, for the benefit of those who believe that the vibration of the cord is due to the fact of the air being stopped from coming out by reason of the approximation followed by the stretching apart of the cords, let it be added that work executed in that manner would be too great a strain on muscles as small as those of the larynx, and that this continuity of movement of the vocal bands, during the production of tone, has not yet been proved by experience.

Also, if the vocal cord engendered the vibration, how could one explain certain affections of the voice, and even certain losses of voice, without lesion of the cords, and how could one understand that an artist should be able to sing with a chronic inflammation of one cord, a case I have observed upon several individuals, and specially upon two tenors who however sang regularly at the Grand Opera. Likewise it has been verified that singers who had muscosities, or a slight swelling on the edge of the cord, could nevertheless deliver easily a series of tones, without letting it be noticed that there could be any disorder of the vibratory part?

How can one explain also the case of an individual suffering of a motive lesion of a cord, as I have had the opportunity of observing only lately, being able to sing with such facility that he created the illusion of being free from any laryngeal disease? This

patient, a bass, had a larynx the right vocal cord of which was fixed in absolute immobility; the left vocal cord joined the right one during the phonation, and the sound came out pure! Again how can one explain that this motionless cord should be able to vibrate in unison with the healthy sound cord?

For all these reasons, I have been brought to think that the voice theory actually current is not satisfactory; therefore one must endeavour to find another explanation.

CHAPTER III.

A NOVEL THEORY OF THE FORMATION OF SOUND.

One must go back to *Savart* to try and understand how the sound can be formed in the larynx without resorting to the tension of the cords and the vocal compensation.

One cannot however accept wholly the ideas of this physician, as for instance when he considers the vocal organ as a conic pipe in which the air is animated by a movement similar to the one it assumes in organ-pipes. To prove the incorrectness of the foregoing opinion, one has only, as *Guillemin* says, to pronounce the vowel *a*, opening the mouth wide, and while one holds the note, to cover and uncover alternately a part of the buccal orifice; the tone of the voice stays at its pitch, whilst the tone of the pipe goes up and down in.

It is another matter when *Savart* states the only difference, between a pipe with membranous mouth and the vocal pipe lies in the mouth-hole which, in the latter, is similar to a *decoy-bird* with upper edges bending inwards.

The decoy-bird is a small cylindric or hemispheric instrument made of bone or metal, etc., and measuring about 20 millimetres in diameter, and half this figure in height; it has two opposite orifices of a few millimetres in diameter. The sportsmen place it between their lips, and by drawing the air with more or less energy past the two openings, they obtain sounds which resemble those rendered by a mouth-piece separated from its pipe.

Altering the cylindric cavity of the decoy-birds, bending in the edges of the mouths, making them thicker, *Savart* has shown that they still sounded; he has joined on to them a wind-pipe and a reinforcing pipe so that the sections of both, this apparatus and the larynx, should be similar (Fig. 37).

He was then able to draw the series of harmonic tones belonging to open pipes *Ut*[1] (*C*[1]) *Ut*[2] (*C*[2]) *Sol*[2] (*G*[2]) *Ut*[3] (*C*[3]) *Mi*[3] (*E*[3]) *Sol*[3] (*G*[3]) etc. exactly as if the upper pipe had been provided with a flute's mouth-piece. He therefore came to the conclusion that the vocal glottis acts in the same way as the vent of the mouth-pipes : the jet of air which comes out of it passes through the space between the ventricles, and strikes against the upper ligaments which act as the level of the organ-pipes, thus producing the tone.

Savart has made the mistake of adding reinforcing pipes to the decoy-bird; sportsmen do not adapt any pipe to their decoy-bird, and nevertheless can draw loud sounds out of it. His fault is to have mistrusted his little instrument. He ought to have said : the parts situated above the ventricles of *Morgagni* (and not the lower vocal cords) are of no avail in the production of the vocal sounds, and these ventricles, with their upper and lower double walls, are quite sufficient to explain all the tones of the voice. The function of the parts placed above the ventricles is to modify, and not to increase the vocal sounds (*Guillemin*).

Figure 37. Section of a decoy-bird with wind-pipe and reinforcing pipe.

It is therefore not without reason that, since the remotest antiquity, the larynx has been considered as the main organ of the phonation; but as this idea has suffered a regrettable deviation since the aforesaid larynx has been reduced to the lower cords only, it is necessary to come back to the starting-point and to say: the essential organ of the phonation is the air current circulating in the ventricles which are moving and changeable, that is alive and animated [1].

Savart has made evident that, by the means of the speed variation of the air current only, the decoy-bird could give all the sounds included in the range of from one and a half octave to two octaves, between *Ut*[6] (*C*[6]) and *Ut*[4] (*C*[4]). With some experience, we can obtain easily deeper tones. « It seems, writes *Savart*, that there is no other limit to this lowering than the one resulting from the difficulty one has in sparing it the wind.. »

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1 In taking from a dog successively the different parts of the larynx from top to bottom, *Longet* has observed that the epiglottis and the ventricular bands could be suppressed without any alteration of the voice resulting therefrom; but it is a different matter with the ventricles : their ablation, as *Hérissant* had stated already, alters entirely the voice. The tone produced by a larynx, reduced to the lower cords only, has no resemblance with the normal voice, which is restored when one places above the glottis a tube of the same diameter as the larynx, and of such length that it may render the series of tones naturally produced by the animal.

The fundamental tone produced by the decoy-bird can be lowered by reason of a weaker wind power, or a lesser rigidity of the walls created by either relaxing or moistening. If one operates on smaller instruments, this lowering is more noticeable. Let me add that the tones are also lowered by the widening of the decoy-bird's central hole, and by incurvation of its edges towards the centre.

On the function of the ventricles. — The ventricles of the larynx fulfill exactly the conditions of the decoy-bird.

The cavities which are included between the lower vocal cord and the ventricular band run horizontally from inside to outside,

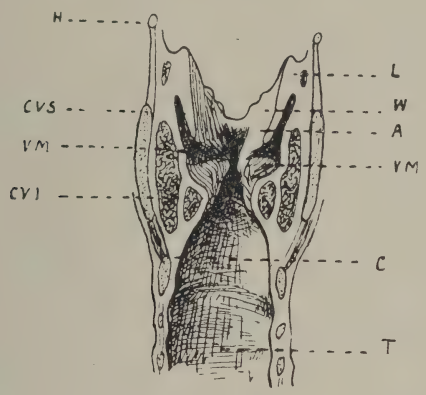

Figure 38.
Transversal section of the larynx.

H hyoide. — *C V S* ventricular band. — *V M* ventricle of Morgagni. — *C V I* vocal cord. — *L* aryteno-epiglottic ligament. — *W* cartilage of *Wrisberg*. — *A arytenoidei*. — *C cricoid*. — *T wind-pipe*.

till they arrive at the shield cartilage, then they bend at right angles and proceed upwards (Fig. 38, *VM*).

Their horizontal portion, writes *Sappey*, has the appearance of a fragment of a disc. The two slightly concaved walls are constituted by the ventricular bands and the vocal cords. The antero-posterior strech of the ventricle, on the level of the glottis, that is at its entrance, has the same length as the cord, but in its course from inside to outside it lessens rapidly. Its greater transversal diameter measures from 6 to 7 millimetres, and its greater vertical diameter, from 4 to 6 millimetres.

As the lower vocal cords are nearer the median plane than the upper ones, the air, at the time of the inspiration, tends to rush inside the horizontal portion of the ventricles; hence proceeds a

remarkable correlation between the development of the latter and the capacity of the chest.

The vertical portion is sometimes very short, or even misses entirely; but often it goes up hill the upper border of the shield cartilage, and, in some instances, reaches the medium part of the thyro-hyoidal membrane and even the hyoid bone. One has sometimes observed it reaching the base of the tongue, and spreading the lingual mucous membrane.

Once, *Sappey* remarked it projecting, on each side, 15 millimetres beyond the anterior face of the epiglottis.

This vertical portion is situated between the upper-glottic portion of the laryngeal cavity and the shield cartilage, on each side of the epiglottis, in the middle of a loose cellular tissue which enables it to be distended by means of insufflation.

Morgagni, who was the first to signal and describe it, had noticed that in raising in inflated backwards. Besides, its shape offers some individual varieties. One observes generally a stricture, mentioned too by the same author, on the level of its continuity with the horizontal portion.

How does the thyro-arytenoid muscle act towards the ventricles? — *Battaille* had already noted that one of the bundles of this muscle formed the lower wall of the ventricles, by spreading from the inner angle of the shield cartilage to the outer edge of the arytenoid cartilage, above another bundle of the same muscle.

According to *Sappey*, the fibres of the thyro-arytenoideus cross obliquely the horizontal portion of the laryngeal ventricles, and it is on the level of the spot where they cross the ventricle, that one observes the narrowing situated between this horizontal portion and the vertical portion.

For *Béclard,* « the out-spread thyro-arytenoid muscles, which « line the bottom of the ventricles of *Morgagni,* increase through « their contractions the rigidity of the ventricle's walls. The effect « of their contractions, without much doubt, is also to modify the « shape and capacity of these cavities by lessening their depth and « also their vertical height, considering the deviation of their fibres « backwards and upwards. »

Hopmann has observed a muscular layer cross the ventricle from top to bottom, and from outside to inside, thus forming a great part of its external wall closely adhering thereon. By contracting, it narrows the ventricles more and more as the tones become shriller.

To this musculo-membranous layer, which forms the antero-external wall of the ventricle, a muscle, described by *Ruedinger,* should be added so as to complete at the top the muscular apparatus. From the back horn of the pyramids, it runs forwards towards

the upper part of the lateral border of the epiglottis. This muscle is more accentuated on a man's larynx than on a woman's.

The ventricles would thus be surrounded on all sides by muscular walls which, with each contraction, would determine a stricture of the cavity and a decrease of its opening.

Let us now examine how the larynx and particularly the ventricles act in the phonation. First of all, it must be observed that the larynx does not stay constantly motionless in the neck : it goes up in the inspiration [1] and in the ascending scale, and, on the contrary, goes down in the expiration and the descending scale. Its lowering facilitates the emission of deep tones; its raising, the emission of shrill tones, a fact that no theory had been able to explain till now, as *Guillemin* points out.

We know too that the larynx rises higher and higher accordingly as we utter the vowels *ou* (oo), *o* (oh), *a* (ah), *é* (a), *i* (e); for *ou* (oo), the position occupied is lowest, for *i* (e) it is highest; this can easily be ascertained on oneself.

The muscular contractions of the thyro-arytenoideus compress the ventricles and lessen their capacity, consequently they raise the tone.

In contracting, the crico-thyroideus causes a swaying movement from one cartilage to the other; this can be easily verified by placing the finger in the intercrico-thyroid space, for the upper ridge of the ring cartilage is then drawn up towards the shield cartilage, which is kept motionless.

Martel has shown, by means of graphic outlines, that during the normal respiration the two cartilages stay at a constant distance from each other, whilst during the phonation the ring cartilage went up and came so much the nearer to the shield that the note was higher.

Thus, in contracting, the thyro-cricoid muscle draws up the front portion of the ring cartilage, at the same time as it gives a swaying movement which carries downwards and backwards its posterior part. In consequence of this movement, the arytenoidei, pulled backwards, draw away the posterior insertions of the cords from their fixed anterior insertions, thus provoking a narrowing of the entrance of the ventricular pockets and a thinning of their walls, contrivance which raises the tone still further.

One can observe these changes of the ventricular opening in certain individuals, specially if one makes use of *Hays'* pharyngoscope.

There is a fact generally omitted by most authors, and that is the movement of the ventricular bands in the phonation.

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[1] Likewise it rises in the first movement of the deglutition, to come back in its initial position in the second movement.

At the time of the production of tone, the vocal cords approximate, the glottis (Fig. 39, *G*) narrows, and the ventricular bands (Fig. 39, *BV*) follow this movement, however they do not come together; but it is easy to ascretain that the higher the tone delivered, the nearer their borders are to the antero-posterior median plane, and the epiglottis itself rises so much the more as the note is shriller.

Trill. — Dr. *Castex* has already observed this mobility of the ventricular bands in the emission of the trill, on the condition that the latter be made on the vowel *é* (a) which raises the larynx. He writes : « The vocal cords are fixed in a position of slight open-« ing. One notices on them neither joinings nor lengthenings; the

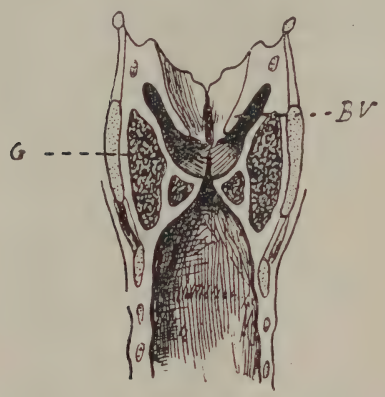

Figure 39.
G Glottis in the phonation.

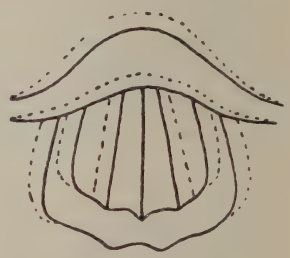

Figure 40.
Larynx in the execution of a trill. The dotted outlines show the extent of the movement executed by the epiglottis, the upper vocal cords and the aryteno-epiglottic folds, while the lower vocal cords stay motionless.

« ventricular bands are animated by a rapid but very short move-« ment which brings them nearer and draws them apart again. An « identical, but much more marked movement stirs the aryteno-« epiglottic folds which form the upper circonference of the larynx. « The movement of the trill is particularly emphasized on these folds, « and can therefore be clearly observed. The epiglottis moves from « front to rear, as if vibrating, falling and rising as quickly as the « two following notes succeed each other; the base of the tongue « follows it in its oscillations, the back pillars of the pharynx (this « last particularity is observable without a mirror, through simple « examination of the throat) come close to each other and separate « again, drawn in an oscillation of equal speed; sometimes the uvula « executes slight movements from front to rear. » (Fig. 40.)

Thus, the trill is an upper-glottic and not a sub-glottic phenomenon.

The laryngeal tones are not governed by the peculiar vibration of the cords, as these do not vibrate and as the ventricular bands

vibrate in a special way « not at the rate of several hundred vibra-« tions per second, so as to give notes, but at the rate of two hundred « per minute at the utmost, so as to regulate the cadence, the succes-« sion of the trill's two notes »; they are not the sonorous body, but the mechanism which changes the dimensions of the ventricular decoy-bird, and allows the air circulating in the latter to alternate the two notes of the trill.

Flatau and *Gutzmann* have photographed the larynx in ventriloquism. So they have been able to convince themselves of the fact that the false cords and the cartilaginous portion of the glottis approximate so closely that they can touch each other. The voice of the ventriloquist is an octave higher than the natural voice; this phenomenon is explained by the maximum narrowing process of the ventricles.

Cyclones. — We are very far from the function generally attributed to the ventricular cavities, which is to allow the vocal cords to vibrate more easily and without obstacles.

The studies of *Lootens* have specially brought a new element to the theory of the formation of the tone.

M. *Van Tricht,* of Namur, after first confirming, has then described the experiments of *Ch. Lootens* who discovered the *cyclones* or *rings* bearing his name, by making tubes sound by means of an air current laden with tobacco smoke, or better still by sounding them in their entire length by means of an apparatus called *rheoscope,* which consists of a brass cord carrying propellors or valves made of elder-wood, the movement of which indicates the direction of these numerous and various currents.

The course of the latter is clearly shown in figure 41.

The air current which has entered into the tube follows path *o;* on ariving at the upper lip of the tube it divides in two currents, the most important of which rushes outside the tube *a, o, b,* the other one, the derivative current, penetrates inside along the elliptic curved wall *a, c, d, e,* to escape later by intermission through *o, f,* but is separated from *a, b,* by a large diaphanous and oscillating sector, rendered visible by the tobacco smoke.

Let me now explain how the same phenomenon takes place either in the cavity of the decoy-bird (Fig. 42), or in the ventricles of the larynx (Fig. 43).

The air current *O, O′,* present in the larynx owing to a slight excess of pressure of the tracheal air over the ventricular air, or in the decoy-bird to a slight excess of pressure of the asmospheric air over the inner air of the decoy-bird, rarified by the pulmonary inspiration, it follows therefore that the entering stream opens in a gerb, and that its borders leave the axis and engender whirling cur-

rents, in the lateral cavities *V*, *V*; these derivative currents come back to strike against the entering air; they compress it a moment and delay its course. Then, being less provisioned, they moderate their force of compression and allow a new expansion of the entering current, before the same efforts are again reproduced.

Thus, the air stream in going through the box of the decoy-bird, or the ventricles of the larynx, undergoes periodical compressions on the part of the whirling air, and in its turn inculcates pulsations of equal period on the one hand to the molecules which run through the lateral vertex, on the other to the atmospheric air or to the pharyngeal air; the effect resulting from these pulsations is similar to the one produced by reeds or syrens, as noted by *Lootens*.

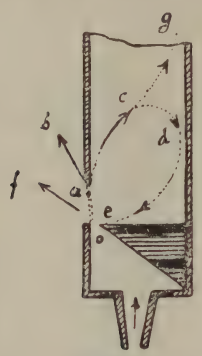

Figure 41.
Course of the cyclones in organ-pipes.

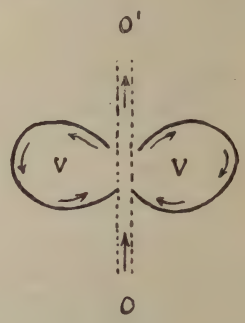

Figure 42.
Course of the cyclones in the cavity of the decoy-bird.

This theory is in accordance with the results obtained by *Savart* with his different bird-calls, and one can apply to the larynx the data furnished by this instrument, therefore :

1° By the sole variation of the air current, one can vary the sound to an extent of at least two octaves[1]. This explains the weakness of the singer's deepest notes, and also the weakness of the breath which gives birth to these notes.

2° By increasing the dimensions of the ventricles in drawing them down towards the base of the neck one gets a deeper tone and, invertedly, by compressing them through a driving back process under the tongue, one obtains shrill notes. Thus, without changing the force of the wind, one can obtain a voice range of two octaves.

3° One can apply to the ventricles, which have soft and moist

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1 According to *Tetrequin* and *Diday*, the voice's extreme notes, either deep or shrill, are not due to the variations in the diameter of the glottis, but to the acceleration, or to the excessive slackening of the expired air. This opinion confirms the theory of Savart.

walls, the data furnished by the decoy-birds which possess relaxed membranous walls; this means that under these conditions the tone goes down and the timbre is altered.

4° The raising of the side of the cord, slowing down and attenuating the coming out of the air column, determines deeper and softer tones, conformably to what takes place in the decoy-bird whose mouth has edges which turn in [1].

5° The sound comes out better when the exit orifice is larger, in other words when the vocal cords are close together and the ventricular bands drawn a little apart [2].

6° The deep tones are produced more easily by wide openings. It is what I have previously stated as regards the opening of the glottis, which is larger for the emission of the deep notes.

7° For an instrument of given dimensions, there is a tone which is delivered more easily and with more intensity than the others; this is the reason why each person speaks naturally in a certain tone, which characterizes the actual state of the organ : thus, « in the morning, when one gets up, the voice is deep, one speaks on the note *La*^{1} (A^1) for instance; during the day one speaks on *Ré*^{2} (D^2); and on *Fa*^{2} (F^2) if one reads aloud. » (*Guillemin.*)

Production of the sound. — The vocal cords being properly approximated, thanks to the constrictor muscles of the glottis, so as to let pass the quantity of air in ratio with the pitch of the tone to be delivered, the tracheal air arrives under sufficient pressure, pressing up and stretching the borders of the vocal ligaments slightly apart, then devides itself into two currents, one of which, t (Fig. 43), is driven out directly, while the other, d, c, penetrates into the ventricles where it follows *Lootens'* law of the cyclones.

The air which comes out of the ventricle in the form of vortex, presses on the tracheal air column, *g*, thus provoking, a first vibration; the other vibrations succeed each other, and are so much the quicker that the circuit to be run inside the ventricle is realized in a shorter lapse of time.

The suppression of the expired air current which manifests itself on the level of the glottis is followed by a depression facilitated

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1 I have had the opportunity of observing upon one of our principal singers a striking example of this modification. For a long time her vocal cords were placed in an horizontal plane, she could hold the part of light sporano, later, the edge of the cords raised, and the voice became deep enough to make some of her former parts difficult for her to sing; but, at the same time, she was now able to approach the dramatic soprani.

2 Dr. Avellis has made the remark that the dimensions of the opening of *Morgagni's* ventricles were larger in singers than in other people. I have been able to verify this fact very often on most artists.

by the current which comes from the ventricle, and strikes the cord's upper-raised border which it helps to lower and bring back to its original place.

Thus the cord is agitated by the aerial current which runs out by saccades at a great speed, and facilitates the entrance of the air into the ventricles.

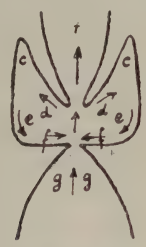

Figure 43.
Course of the cyclones in the larynx.

The expiratory air current, coming out under strong pression, aspires the air in the ventricle and determines a decrease of the pressure; then this pression diminishing in the wind-pipe, the latter goes up in the ventricles where the air draught becomes less. In this manner the changes of pressure succeed each other during the production of the tone, and engender a regular beating.

Qualities of the sound. — These qualities depend from the intensity, the pitch and the timbre.

Intensity. — The intensity, or force, or loudness of the sound, is due to the power of the expired air current; this proves the importance of having a good breathing when one sings.

The intensity of the sound is reinforced by the vibrations of the air masses contained in the sub and upper-glottic cavities, and by those of the walls of these cavities. It is for this reason that the voice is more powerful when the chest is larger and more spacious.

The intensity is also influenced by the density of the air : the more condensed is the latter the more sonorous is the tone; on the contrary, the air is propagated in vacuum.

Lastly, the intensity depends on the distance, it is proportionate to the inverse ratio of the square of the distance at which the sonorous body is placed. Every artist should remember this principle, when singing in more or less roomy halls.

Pitch. — The pitch, or height of a tone, depends upon the number of vibrations produced per second; it is in ratio to the speed of the running out of the tracheal air.

The tones which are perceived by the extend from Ut^2 (C^2) (16 vibr.) to Ut^{10} (C^{10}) (35,400 d. vibr.) but the limit of the musical

sounds is lower, specially as regards the high tones, where it scarcely exceeds La^6 (A^6) (3,480 d. vibr.).

Vibrations and periods. — The vibrations of the tuning-fork are reckoned per second; in France, the normal diapason, La^3 (A^3), gives 870 simple vibrations, or 435 double vibrations per second.

As the vibrations are not reckoned in the same way in France as in other countries, and as the pitch of the normal diapason varies also according to the different states, it is useful for the musicians to consider this question for a moment.

In France, the name of vibration is given to the displacement of a sonorous body on one side only of its equilibrium position, which means that the movement of to-and-fro is counted as two vibrations, contrary to the method accepted in England and in Germany, where the vibration is considered to be the whole of the movement periodically repeated; this means that the movement in one direction, and the inverse movement which brings the body back to its equilibrium position is counted as for one simple vibration; therefrom follows that the same tuning-fork gives 16 double vibrations (England and Germany) and 32 simple vibrations (France).

But as it is not necessary for the sonorous vibrating movements to be symmetrical but periodical, it is not logical, because of this dissymmetry, to reckon the movement in one direction as a first vibration and the opposite movement as a second one, as for the quite similar oscillations of the pendulum.

It would even be advisable to use the word *period* instead of vibration; this expression would be more correct and, at the same time, would prevent any confusion from occuring when the word vibration is used, without mention being made, if the latter is simple or double.

Pitch of the normal diapason. — Its variations. — The pitch of the normal diapason has often changed, and actually the musicians have not yet come to an agreement as to the adoption of an universal diapason.

Sauveur, who was the first to study, the question of the absolute pitch of the notes, found that the lowest *La* (*A*) of the harpsichord gave 202 simple vibrations, and *Ut* (*C*) of the bottom of the harpsichord, or of an open-pipe measuring 8 feet, 244 simple vibrations; therefrom would result that La^3 (A^3) would have 810 simple vibrations (*Radau*). Such was the normal diapason adopted at the court of Louis XIV.

During the preceding century, this La^3 (A^3) had varied from between 820 to 850 simple vibrations. *Sauveur* suggested that one should adopt as fixed tone the tone having exactly 200 simple vibrations per second, and which he believed to be the *La* (*A*) of an open

organ-pipe, measuring 5 feet. But having realized later that *La*^{3} (*A*^{3}) was in fact slightly higher, he asked *Ut*^{3} (*C*^{3}) with 512 simple vibrations to be taken as fixed tone.

After him, *Chladni* adopted *Ut*^{3} (512 s. v.) and having as corresponding tone *La*^{3} (*A*^{3}) with 853.5 simple vibrations.

In 1833, *Scheibler* examined the diapason *La*^{3} (*A*^{3}) of the principal theatres and found out that the Paris Opera possessed two of them, one of 853 simple vibrations, the other of 868; in Paris again, at the Italians and at the Conservatoire, the diapasons varied from 870 to 881 simple vibrations, in Vienne, from 867 to 890 simple vibrations, in Berlin, the diapason had 853 simple vibrations.

Accordingly to prevent the continual raising of the tone of the orchestras, the German natural philosophers decided, at the Congress of German Scholars held at Stuttgart in 1834, to adopt Scheibler's suggestions and fixed the *La*^{3} (*A*^{3}), or German *a*^{1}, at 880 simple vibrations [1].

The theatres of the principal towns in Europe continued to make use of different diapasons, the pitch of which went progressively up, so that in 1855, in Paris the *La*^{3} (*A*^{3}) of the Opera gave 880 simple vibrations, and in 1857, the same sound of the Opera and of the Italian Theatre went to 896 simple vibrations; the diapason of the Berlin Opera, to 897, and the one of the San Carlo Theatre at Naples, to 890; the one of the Scala, at Milan, to 903, and lastly the one of London to 910 simple vibrations.

To put an end to this incessant progression of the normal diapason, after the studies of *Lissajous*, a ministerial order, dated from the 15th February 1859, fixed for France the normal diapason La^3 (A^3) at 870 simple vibrations, or 435 double vibrations per second, at a temperature of 15 degrees (centigrade thermometer), this gives 522 simple vibrations to *Ut*^{3} (*C*^{3}) and 130.5 to *Ut*^{1} (*C*^{1}), the deep *Ut* of the violoncello.

An universal agreement is still far from being come to as regards the normal diapason, for the German *c*^{1} which corresponds to the French *Ut*^{3} must give, according to *Helmholtz* and *Bezold*, 256 double vibrations, figure which is the same as the one proposed by *Sauveur* and *Chladni*; according to the Paris Conservatoire, 261 double vibrations; and according to the scale of the natural philosophers, of *Ptolemy* and of *Scheibler*, 264 double vibrations; therefore the German diapason *a*^{1} which corresponds to the French *La*^{3} has 426.6 double vibrations or 853,3 according to *Sauveur*, or 435 double vibrations according to the French ministerial order, or yet 440 double vibrations according to the Congress of Stuttgart. In fact, it is *Sauveur's* diapason which has been accepted in Germany.

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[1] It must be borne in mind that in England the sounds of the scale are indicated by the letters *C, D, E, F, G, A, B,* corresponding to the French *Ut, Ré, Mi, Fa, Sol, La, Si.*

Equally divergent is the method of indicating the octaves. In France, some authors number in the following way the series of the different scales : *Ut*-$_2$, *Ut*-$_1$, *Ut*-$_0$, *Ut*, *ut*..., others mark them as follows : *Ut*-2, *Ut*-1, *ut*...

In Germany, one uses the following designations : *C*-$_2$, *C*-$_1$, *C*, *c*, c^1, c^2, c^3 [1].

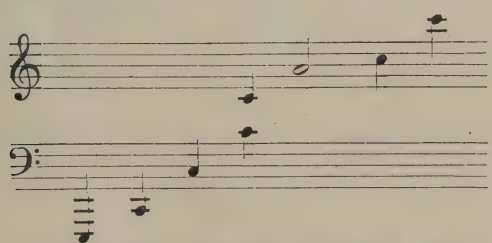
The Italians have adopted the following annotation :*DO*-2, *DO*-1, *DO*, *do*, do^1...

Octaves. — The table below shows the ratio in with the octaves stand towards the frequencies of vibrations, the normal French diapason , giving 870 simple vibrations, or better 435 periods, having been adopted here.

	Octave	Feet	S. Vib	Periods	French notation	Greman notation	English notation
Sub-counter Oct.	10m,52	32	32,5	16	Ut^{-2}	*C*-2	*C* 1
Counter-Octave	5,26	16	65	32,5	Ut^{-1}	*C*-1	*C* 2
Major-Octave	2,63	8	130,50	65	ut^1	*C*	*C*
Minor-Octave	1,32	4	261	130,50	ut^2	*c*	*c*
Octave *i*	0,65	2	522	261	ut^3	c^1	c^{I}
Octave *ii*	0,32	1	1044	522	ut^4	c^2	c^{II}
Octave *iii*	0,16	6 thumbs	2088	1044	ut^5	c^3	c^{III}
Octave *iiii*	0,08	3 thumbs	4176	2088	ut^6	c^4	c^{IV}
Octave *iiiii*	0,04	18 linis	8352	4176	ut^7	c^5	c^{V}
Octave *iiiiii*	0,02	9 »	16704	8352	ut^8	c^6	c^{VI}

Figure 44.
Table of the octaves with the number of vibrations.

Musically, these scales would be written in the following way, in starting from the Counter-Octave :



	Ut-1	ut^1	ut^2	ut^3	La^3 normal	ut^4	ut^5
Simple vibrations.	65	130,5	261	522	870	1044	2088
Periods.	32,5	65	130,5	261	435	522	1044

Figure 45.
Table of the series of scales according to the musicians.

[1] In England *B* takes the place of *H*.

The deepest organ tone which is given by a pipe of 10 metres, or 32 feet, is the first tone of octave-$_2$. It corresponds to 32,5 simple vibrations per second.

The deep *Ut* (*C*) of the piano begins at octave-$_1$; its ratio of frequencies is 65 simple vibrations. The *Mi* (*E*) of the same octave is the deepest tone of the double-bass, and the *Fa* (*F*) is given by the longest cord of the harp. The first tone of the octave is furnished by the thickest cord of the violoncello Ut^1 (C^1) = 130,5 simple vibrations.

Ut^2 (C^2) is the deepest tone of the alto; Ut^3 (C^3) the deepest tone of the flute. Octave^4 begins by the deepest tone of the small flute.

Air speed. — The sound travels in the air at a rate of about 333 metres per second.

It is a matter of interest to know the path of the aspired air through the aerial passages.

Cagniard de Latour has measured the pressure, or more exactly the excess of pressure of the tracheal air over the atmospheric air upon a man who had an opening of the wind-pipe, in consequence of having undergone the operation of tracheotomy. He has found it equal to 160 millimetres for the tones of medium pitch, to 200 for the high sounds, and even to over 900 for the shouts; these pressures are manifested by some speeds of 49 metres for the expired air glottis in ordinary voice.

If one compares this speed with the speed of the wind, one is surprised to see the force of the tracheal pressure. Indeed the speed of a light breeze which is compared to the speed of a slow train is 6 metres per second, the speed of a strong wind (fast train) is 15 metres, the speed of a tempest (swallow's flight) is 29 metres, and the speed of a hurricane, 40 metres.

The tracheal air arrives on the level of the glottis at a speed varying from between 20 to 120 metres per second.

The greater the speed of the air current the quicker are the vibrations and the shriller the tone.

Timbre. — It is the quality of the tone by which are distinguished tones of equal pitch an intensity, but produced by different instruments. It is owing to the timbre that one can recognize a person by his or her voice.

It is during its progress through the cavities, called upper-glottic cavities of resonance, that the original laryngeal sound acquires the third quality of the tone : the *timbre*.

Descartes, and later *Rameau*, had already begun to realize this question. The latter had observed that when a note is executed

with care, one realizes the existence of several simultaneous tones which are added to the tones determining the pitch of the note heard, but have a far lesser degree of loudness.

The organ manufacturers on their side had found, after much groping, that the tone of a pipe was fuller when a complement of 3 to 7 tin pipes added thereto, giving higher sounds than the prime note, and tuned at an octave or a fifth above each other. The sympathetic pipes made the ear experience the effect of one single note which was, in that case, the deepest of the whole assemblage.

Helmholtz has based his theory on this same principle : that each prime tone is only a compound of notes, an *assembly*.

To the ear capable of analyzing tones, certain sounds give the impression of a single note : these are the simple tones. Contrarywise, the tones in which can be distinguished the accessory notes are called *partial* tones, or *compound* tones. The notes which add themselves on the prime tone are the *harmonics*.

Accordingly to *Helmholtz*, the harmonics are not distributed at random; their difference of superposition to the prime tone engender the differences of timbre. They are borne at the same time as the prime tone, and result from the accessory parts of the instrument as, for instance, the wall of the organ-pipe, the wood of the violin or of the flute.

Certain harmonics produce with the prime tone a disagreable impression. The singers and the violonists sing or play instinctively so as to give out these inopportune harmonics.

When several musical sounds are delivered at the same time, to be pleasing to the ear they must form a consonance which is the duration of their vibrations where the prime tones are concerned, and consequently the allowed harmonics are in simple ratio as 3, 4, 5, 6, 8, 9, 12.

In the voice, the harmonics are reinforced by the upper-glottic cavities of resonance.

Helmholtz has studied the harmonics by the means of resonators, which consist of a globe made of glass or of a hollow cylinder with two openings, one of which, the longest, is turned towards the vibrating body, whilst the other, the smallest, is adapted to the ear.

Each resonotar vibrates for one particular note or one of its harmonics, and this note is the note it would produce if it was made to render a tone directly.

The box of resonance and the sonorous pipe of the music instruments have a similar function to the resonator. If one vibrates a string between two nails, the tone becomes very sensible only if a violin is put in communication with one of the nails, for the vibrations of the string are then transmitted to the air contained in the

box through the resonating parts of the instrument : the sound-post and the F-hole.

The cavities of resonance : sub-glottic cavity or laryngeal aditus, pharynx, mouth and nasal cavities, act in the same way as the table of the violin, with the difference that they are contractile, that is capable of changing of shape. ,

But this theory of *Helmholtz* is strongly shaken nowadays, as will be seen further, and for my part, in accordance with certain natural philosophers, I reject it on account of reasons stated in due course.

CHAPTER IV.

STUDY OF THE VOWELS AND THE CONSONANTS.

Vowels. — Until quite recently, on the faith of *Helmholtz*' s researches, it was believed that the vowels were due to the reinforcement of the prime laryngeal tone in the upper-laryngeal cavities of resonance, ventricles included, by a fixed note belonging to the series of the larynx's harmonics to which *Jamin* has given the name of *vocable.*

Thus, each vowel would be due to the laryngeal sound reinforced by its vocable. In other terms, the vowel would be a special timbre communicated to the song or to the speech by the fixed tone of pitch, corresponding to the shape given to the mouth for the voice emission.

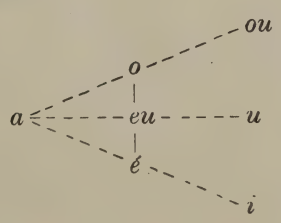
Already, in 1850, before the researches of *Helmholtz, Grassmann* had classed the vowels according to three series :

1° *ou, u, i.* characterized by a single harmonic. This sole harmonic would be lower than Ut^5 (C^5) for *ou*; it would be included between Ut^5 (C^5) and Mi^6 (E^6) for *u*, and for *i*, it would be placed above Mi^6 (E^6).

2° the vowel *a* would be accompanied by a series of nearly equal harmonics.

3° *o, ou, é,* would be intermediate between *a* and one of the vowels of the first series.

Thus, one would have :



Donders, Helmholtz, Koenig, Auerbach, etc., have admitted the fixedness of the various vocables, with pitch independent from the tone of the note sung. The following table gives the results of the notes these natural philosophers have obtained for the vowels.

	ou	*o*	*a*	*é*	*i*
Donders	fa^3	$ré^3$	$si\flat^5$	$ut\sharp^5$	fa^5
Trautmann	sol^4	$ré^5$	fa^5	$ré^6$	fa^6
Auerbach	fa^3	la^3	fa^4	la^3	fa^3
Helmholtz	fa^2	$si\flat^3$	$si\flat^4$	$si\flat^5$	$ré^6$
R. Koenig	$si\flat^2$	$si\flat^3$	$si\flat^4$	$si\flat^5$	$si\flat^6$
Bourseul	ut^4	sol^3	mi^2	fa^3	
L. Hermann	ut^4 - $ré^4$	$ré^4$ - mi^4	mi^4 - sol^4	si^5 - ut^6	$ré^6$ - sol^6
Samojloff	ut^3 - sol^3	si^3 - $ré^4$	sol^4 - la^4	si^4 - $ré^5$	$ré^6$ - mi^6

To obtain these notes, *Donders* proceeded by listening to the tone of the whispered vowel, and *Trautmann* tuned the tuning-forks to the sound of the whispering of each vowel; *Auerbach* used to determine the tone given by the larynx when struck with the finger, just as it was about to render the vowel; *Helmholtz* listened to the tone of the vowel reinforced by a resonator; *Koenig* appreciated the maximum reinforcement of the sounds of a tuning-fork vibrating before the mouth disposed as for the production of the vowel; *Bourseul* listened to the sound yielded by the teeth struck with the finger, the mouth being placed in the correct position for the pronounciation of the vowel.

The results obtained by *L. Hermann* and *Samojloff* are due to the graphic method of which further mention will be made.

Other authors believe that the vocables are the exact harmonics of the tone of voice or laryngeal sound, and that the order of these characteristic harmonics, prevailing in intensity, varies with the different vowels, but is always the same for each of them (*Grassmann*).

The auricular method which determines the vocables, by means of a turning-fork or a resonator, leaves too wide a field to personal appreciation to be of sufficient weight. The above quoted results are a proof thereof as no two experimenters have been able to concord, regarding the tone delivered.

Registration of the vowels. — Other processes have been made use of for the study of the vowels : for instance, *Koenig* and *Doumer* have employed manometric flames, and *Jenkin* and *Ewing*, and later *Schneebeli*, curves by which means they were able to analyse the vowels graphically.

Manometric flames. — The apparatus made by *Koenig* consists of a small box, a wall of which is formed by a vibrating membrane

set into action by speech; two tubes are fitted to it : one brings the lighting gas, and the other, which ends by a burner, lets this gas out and enables it to be lighted. A revolving mirror is placed before the flame so as to render its variations visible (Fig. 46). If the

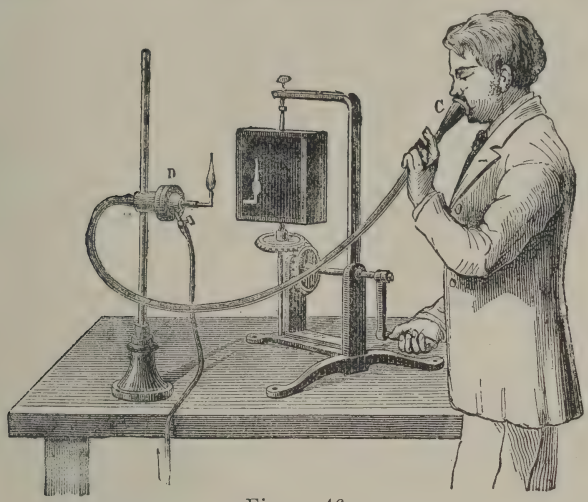


Figure 46
Mr. Koenig's apparatus with manometric flames.

flame does not vary in height, one perceives a luminous band; in the opposite case, the flame offers indentations. *Stein*, by replacing the coal gas by cyanogen has been able to photograph the flames.

Figure 47.
Characteristic flames of the vowels *ou, o, a, é, i* after *R. Koenig.*

Marbe has registered the vibrations of an acetylene flame, by making a piece of paper run quickly above it; the vibrations are inscribed on the sheet in the shape of a circular ring of light smoke.

In figure 47 are shown some of the results obtained by *Koenig.*

Graphic methods. — The graphic method must forcedly give more precise information than the above mentioned processes, as it proceeds to inscribe, by the means of appropriate transmissions, the movements of the particular organs during the voice formation.

Young, in 1807, was the first to have the idea of inscribing the voice on a moving cylinder covered over with a sheet of paper blackened with smoke. In 1857, *Lissajous* succeeded in registering the curves of the tuning-fork by placing a small mirror at the extremity of one of its tongues. About 1860, a typographer, named *Léon Scott*, described his *phonautograph*, composed of a trumpet conducting the sound onto an elastic membrane, on which was fixed a point designed to inscribe the vibrations on a revolving cylinder (Fig. 48).

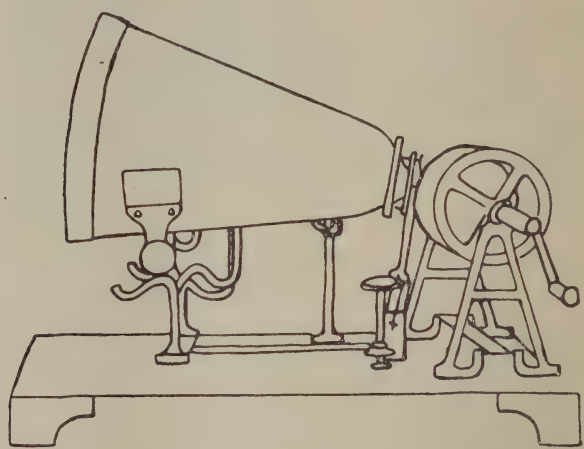


Figure 48.
L. Scott's phonautograph.

It is by means of this apparatus that *Donders* obtained the first graphs of the voice tones. *Barlow*, in 1874, made use of a similar instrument, called *logograph* the point of which, consisting of a brush soaked with paint, marked the vibrations on the paper band of a telegraphic apparatus.

Dr *Boudet de Paris* used the telephone and the microphone, in which he replaced the membrane by a registering lever.

Abbé *Rousselot*, to the same effect, had recourse to a microphone, provided with an electro-magneto to which a point was adapted, and to its *registering ear*, composed of a membrane made of a pork bladder, which was placed at the same angle as the drum of the ear, and which carried a registering point. One speaks in a mouth-peace joined to the apparatus by a short india-rubber tube.

With an instrument resembling at the same time *Scott*'s phonautograph and the telephone, *Schneebeli* obtained the following graphics of the vowels thanks to a system of amplification consisting of a lever, the shorter arm of which rested upon the centre of the membrane (Fig. 49).

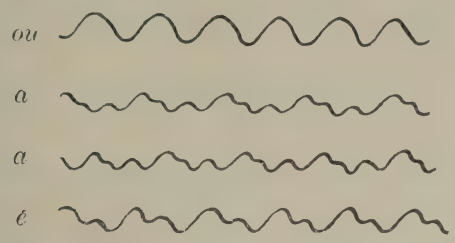
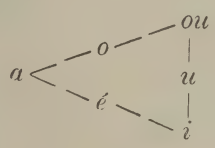


Figure 49.
Vowels after Schneebeli. Sung on Ut^4 (C^4).

According to him the spoken vowels are characterized by a type corresponding to a vibration or period in the case of *ou, u* and *i;* by a group of two periods for *o* and *é*, and by a group of three for *a*, as shown in the following table :



Dr. *Marage* has adopted this classification; but if one compares the graph of the vowel drawn by him, and shown on figure 39 of

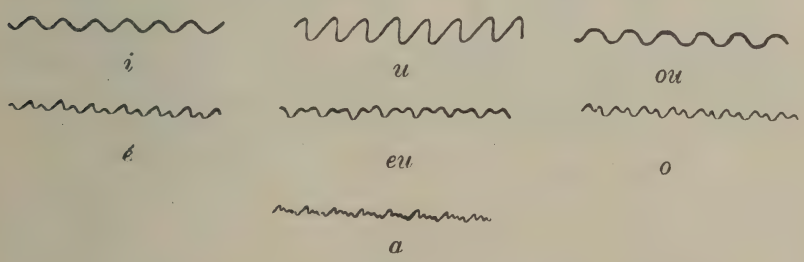


Figure 50.
Graph of the vowels after the loose sheets of the manual handed at Dr. *Marage's* lectures and in his book « *De la théorie de la Voix* » (1900).

the loose sheets of the manual handed at his lectures, with the graph represented figure 52 of his book which came out a few weeks later,

one is surprised to see that the graphs of *a* are different in both publications (p. 85 in both books). In the first one, *a* is clearly formed by a group of four vibrations (Fig. 50) whilst in the second one (Fig. 51) only three are drawn.

In both figures, the graph of which M. *Marage* has given as being the graph of *a*, after *Schneebeli*, is completely different to the one represented in figure 49 taken from *Schneebeli*.

Figure 51.
Graph of vowel *a*, after his manual published a few weeks later (p. 85, Fig. 52).

Phonograph. — In 1877, *Charles Cros* described a process which consisted in obtaining the graph of the to-an-fro movement of a vibrating membrane, and in using this graph to reproduce the same

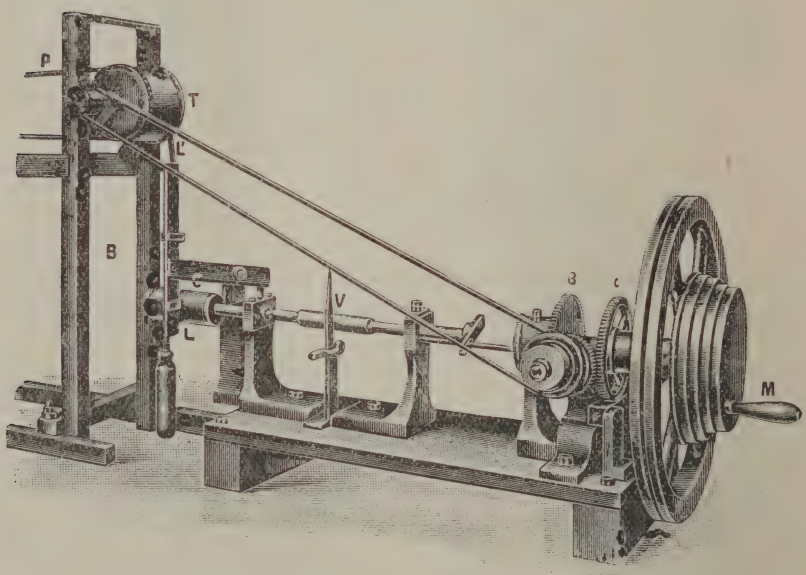


Figure 52.
Lioret's apparatus for enlarging phonographic sketches.

to-and-fro movement with its intrinsic ratio of number and intensity. Later, he used the galvano-plastic moulding of a graph made on smoked paper; he called this apparatus a *paléophone*, a name which was changed into the one of phonograph by Abbé *Lenoir*, whose nom de-plume is Abbé *Leblanc*.

In January 1878, *Edison* took a patent for a cylinder covered over with a tin sheet on which a ridge was made with a point. In making a needle pass again over this hollow, *Edison* succeeded in reproducing the voice. Later, he made use of wax cylinders, at the instance of *Lambriget,* an officer of the Administration of telegraphic lines, who constructed a phonograph in which stearine was used to inscribe the vibrations of the voice. He obtained, by means of galvano-plastic art, a copper deposit which reproduced the striæ of the cylinder in opposite direction and, by passing a plumb-line over the striæ, he provoked the production of the tones inscribed on the apparatus.

Hauser made use of the *gramophone* to inscribe the consonants which *Wendeler* had already tried to represent graphically.

To be able to read easily the phonetic registrations, *Bocke, Hermann, Marichelle* used the microscope.

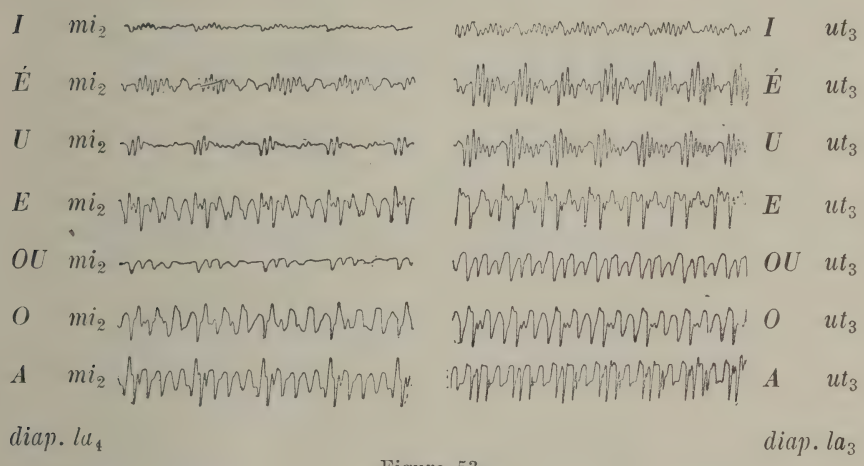


Figure 53.
Vowels as uttered by a man's voice (Laboratoire de l'Institution nationale des Sourds-Muets de Paris).

Already in 1878, *Alfred Mayer* made use of an amplifying lever which traced on a blackened glass the profile of the risings and depressions made by the point on the registering cylinder. *Jenkin* and *J. A. Ewing, J. Lahr, L. Hermann, Scripture, Frazer, Schneebeli, Lioret, etc...* followed his example and used a luminous or mechanical lever.

Lioret's apparatus is very simple and very practical, one can obtain with it enlargements which go from 300 to 1,000 times in breadth and to 3 1/2 in length (Fig. 52).

In figure 53, obtained with this apparatus, are represented the different vowels uttered on *Mi*^{2} (E^2) and *Ut*^{3} (C^3).

In figure 54, borrowed from *Hermann*, are given the graphs of the scale on the vowel *a*, which have been obtained by means of the photography of a luminous ray, reflected upon a mirror, the movements of which reproduce always the sinuosities of the registered ridge.

The reading of these graphs shows clearly that the periods are not all equal for the same vowel sung on different notes. Therefore the graphs of the phonograph contradict on every point those of *M. Marage*. « The imperfect results obtained by this author are due both to the defect of the apparatus used by him, and to the insufficiency of his experiments. » (*H. Marichelle.*)

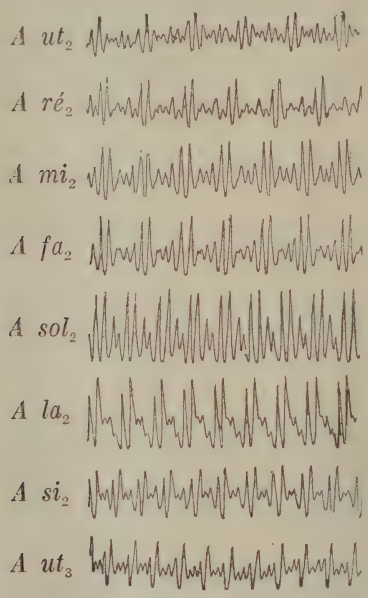


Figure 54.
Scale on the vowel *a* after *Hermann*.

Photography of the voice. — By making use of a process already employed by *Stein* and *Vogel*, *E. W. Blake* was able to photograph the vibrations of the telephone membrane; he adapted to the plate of the latter a steel wire bearing a mirror on which a luminous ray was thrown; this ray reflected itself in the focus of a lens, on a variable plate which moved at a constant speed. In this manner *Blake* obtained the following graph (Fig. 55).

A telegraph engineer, *Devaux-Charbonnel*, has made use of a microphone and of *Blondel*'s oscillograph, which supports a mirror placed between the armatures of an electro-magnet. The mirror

reflects the rays coming from an arc-lamp on to a protographic plate where the movements of the mirror are recorded.

In 1889, *Hermann* photographed the oscillations of the vowels and of the consonants, by means of membranes provided with mirrors; and, in 1893, he utilized the phonograph with a similar arrangement.

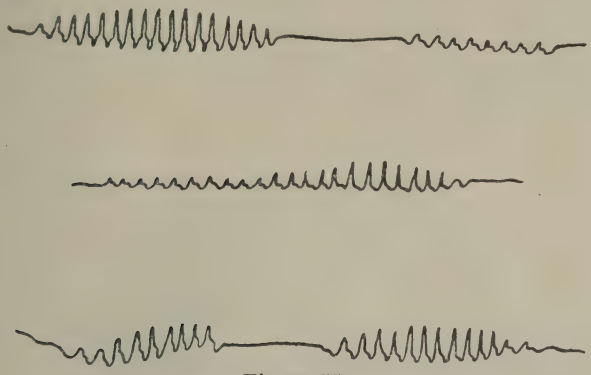


Figure 55.
Photography of the voice obtained by Blake.

In the same year, *Rapps* collected the vibrations produced in the open air by human voice, by means of an oblique mirror, *M*, on which he threw a very strong light. In arriving there, one of the

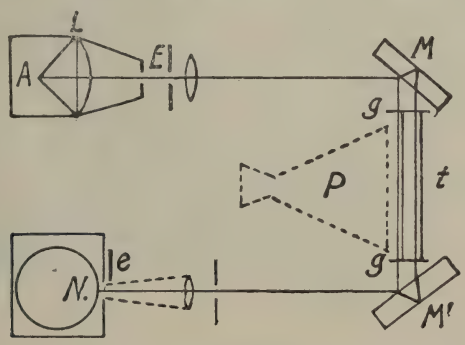


Figure 56.
Arrangement by *Rapps* for photographying the voice.

pencils of the rays goes through the tube, *t*, which is shut at both ends by an overlapping glass, *g*, *g*, the other one passes through the open air, and both concentrate on the second mirror *M'*, from where they are projected in the dark room, *N*, where a sensitive sheet of paper unrolls itself perpendicularly to the aperture. At a small distance from the tube, *t*, is placed the mouth-piece of a speaking-trumpet, *P*, in which the vowels are sung (Fig. 56).

For the same purpose, Dr. *Marage* uses a vibrating membrane placed at the bottom of a mouthpiece, and carrying a small plane mirror which is adapted to *Pollak-Virag*'s apparatus of fast telegraphy. He also takes advantage of the luminous source of this instrument to light the mirror, the vibrations of which are inscribed upon the phtographic paper. To complete this apparatus Dr. *Marage* has made a special arrangement which enables the sensitive paper to pass successively through two developing baths, and through a fixing one, whence it is possible to obtain immediately the proof of the negative.

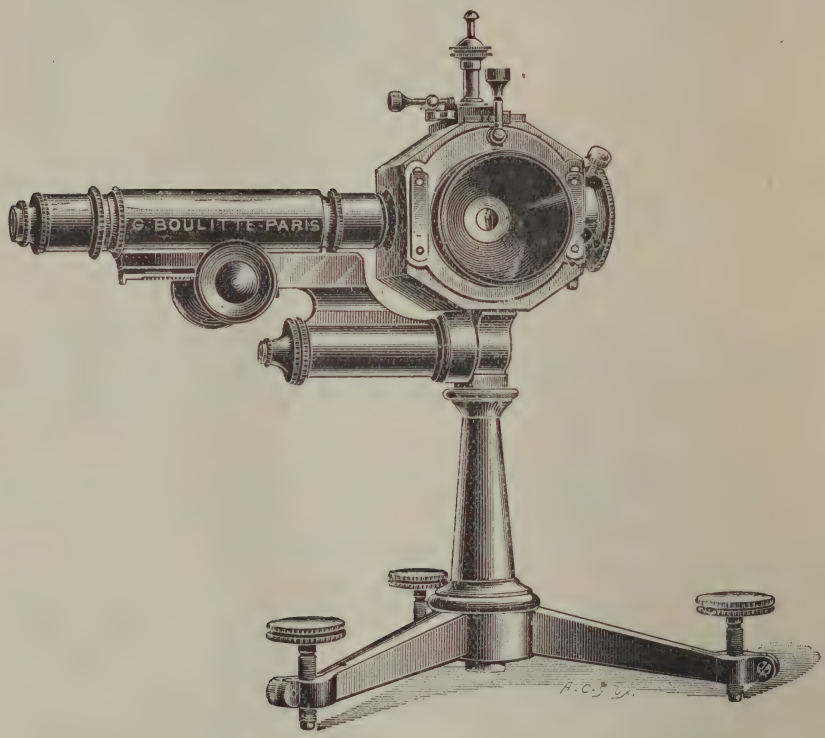


Figure 57.
O. Weiss's phonoscope.

Let it be added that I have not been able to find in the negatives accompanying his *Manual of physiology of the voice* (Fig. 53, 56, 91, 92, 94, 95, 100 and figures following) one single characteristic graph of the vowels and consonants, as these negatives are not clear.

Furthermore, it is materially impossible for the reader to appreciate the musical pitch of the notes photographed in this work,

while, on the contrary, I can easily do so on the graphs I give further and which have been taken at the laboratory of *M. Marichelle*, with the kind cooperation of the Director.

Some years ago, with the purpose of registering the voice, I had made use of an apparatus built specially for the inscription of the heart noises. With this phonoscope of *O. Weiss* (Fig. 57) one is able to register photographically the vibrations of a membrane formed by a soap bubble, and therefore of an extreme tenuity and mobility. The vibrations are transmitted to a small lever of silvered

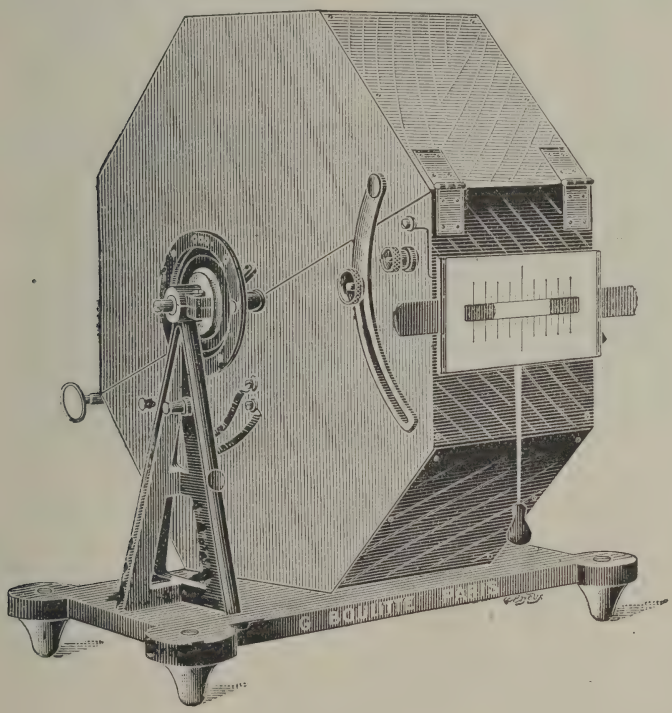


Figure 58.
Bull's photographic registering apparatus.

glass, the extremity of which comes into contact with the membrane. The glass lever itself is placed at the focus of a microscope which projects its enlarged image on the slit of a registering apparatus, as, for instance, *Bull's* apparatus (Fig. 58), inside which is a band of sensitive film.

Here is an *E* registered with the apparatus (Fig. 59).

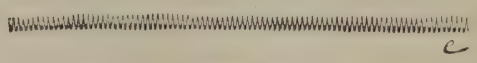


Figure 59.
E registered with *Bull's* aparatus.

As this apparatus is so sensitive as to be impressed by the vibrations from the street, I have preferred to make use of *Lioret's* apparatus, which has also the advantage of giving clearer views.

Dr.*Struycken* has built a cubic chamber with walls consisting of tissue paper. In the centre of each membrane is fixed a wire which runs to the median portion of the box, so as to support a wire bearing a mirror (Fig. 60).

When impressed by feeble sounds, the two membranes vibrate and imprint on the luminous pencil falling on the mirror movements

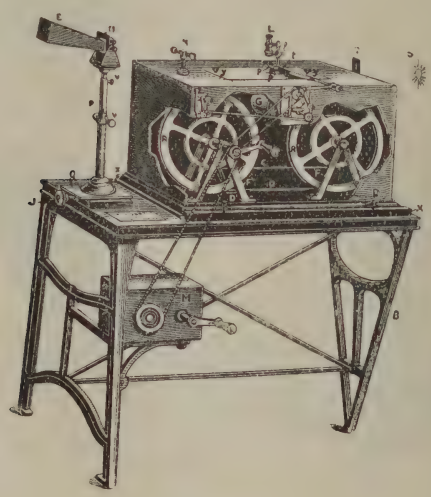


Figure 60.
Struycken's apparatus.
E bell. — *H* mirror-stand. — *RR* wheels for turning the paper. — *G* drum for the proofs. — *S* luminous source. — *M* motor.

of oscillation which are photographed by means of glasses provided with an oscillating prism.

Thanks to a modification brought by Messrs *Marichelle* and *Lioret,* one cannot only see the vibration in proportion as it is

produced, but even project it on a screen outside the apparatus; this improvement can be of great utility in the tuition of song and speech, as well in the schools of lyric declamation as in the institution for deaf and dumb.

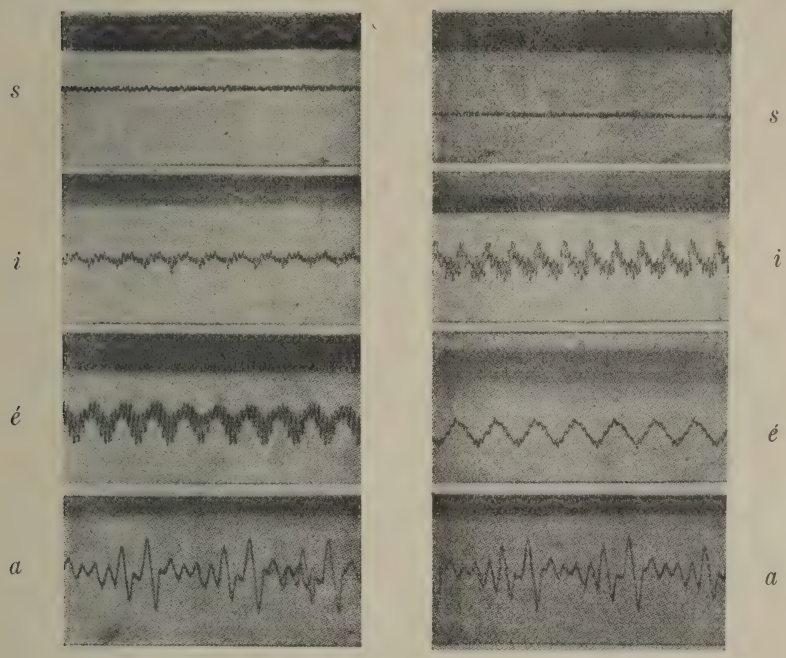


Figure 61.
Graph of different vowels obtained with *Struycken's* apparatus.

The differencies between the graphs, seen on the right and on the left, are due to the speed of the paper and of the uttered vowel which are not the same in the two cases.

CHAPTER V.

EXPERIMENTAL PHONETICS.

By experimental phonetics one understands the means of which we dispose for judging of the condition of the vocal organs and finding out how they work.

It is of all necessity that the singing-master should be well acquainted with their working, and capable of appreciating the results thereof.

Besides the various instruments previously mentioned in connection with the respiration, and which give information regarding the perviousness of the nasal cavities, the measurement of the amount of air contained by the lung, the dimensions of the thoracic perimeter and the amplitude and duration of the movements of the thorax, one must also make use of an apparatus for the registration of the voice, as *Lioret*'s apparatus for instance, which is very practical and convenient to handle; lastly one must have recourse to a series of processes through which valuable indications can be got concerning the working of the larynx and the upper-glottic cavities.

Photography. — The photography of the mouth shows us what are the positions taken by the lips in the articulation of the vowels and consonants, and also what are their various forms of opening according to the different letters, and in what way the soft palate works during the production of certain vowels.

As regards the larynx, let it be borne in mind that since the beginging of laryngoscopy one has attempted to photograph this organ. In 1861, *Czermak* used to this effect a dark room provided with four objectives, two of which were intented for the stereoscopic images, another one for the ordinary images, the last one serving as view-finder.

Th. French, of Brooklyn, began his experiments in 1882, and after having taken more than 1,500 negatives, was finally able to obtain some pictures of the larynx by making use of a dark room on the side of which was adapted a pharyngeal mirror. The patient

was asked to sit with the back to the sun, and *French* sent back the rays on the laryngeal mirror by means of a frontal mirror. He made use also, with greater success, of a voltaic arc of two thousand candles with concentrator. But the adjusting of this apparatus offers great difficulties.

All the apparatus employed till now have not given better results than those obtained by *French*.

In his first experiments, Dr. *Garel*, of Lyon, has simplified *French*'s apparatus by replacing the glass plates by films. His apparatus consists of a rectangular box twenty centimetres long and five centimetres wide and deep; it is provided with two objectives and a laryngeal mirror. Dr. *Garel* has recently altered this apparatus (Fig. 62).

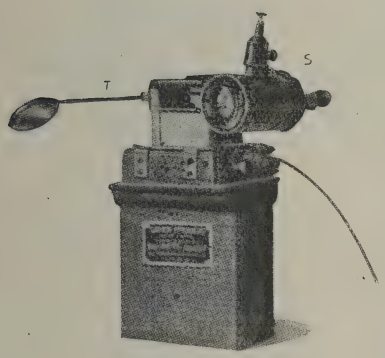


Figure 62.
Dr. *Garel's* improved apparatus for obtaining stereogrammes of the larynx.

Figure 63.
Photograph of the larynx, after a plate by Dr. *Garel*.
a a vocal cords. — *b b* pyramids. — *c c* aryteno-epiglottic folds. — *d* epiglottis.

We are giving here a photograph obtained with this instrument during the phonation (Fig. 63).

Kahler has disposed upon the outer end of *Hays*'s pharyngoscope (Fig. 28) an arrangement which makes it possible to take alternately eight views, either snapshot or time-exposures. But the light given by the lamps of a few candles only is not sufficient. Furthermore the photographs obtained have to be enlarged.

The photography of the larynx renders great services, as it enables the observation of the position of the cords in the different voice registers, and of the lesions which can affect the organ of the voice.

Cinematograph. — The cinematograph is very useful as it can give us the series of the movements of the lips; one can foresee that in the near future one will be able to use it for studying the play of the

vocal cords, as it has already been done by Melle *Chevreton* and Mr. *Vlès*.

X-Rays. — I have already stated the utility of the X-Rays in the study of the respiration, specially during the movements of the midriff; they disclose also the play of certain parts of the vocal organ. Though the presence of the maxillary and of the teeth is a serious obstacle in this special instance, a few of my colleagues have been however able, notwithstanding these difficulties, to make some interesting observations. Scheier, for instance, has studied the position of the larynx in the emission of vowels. He has noticed a lowering of the lid in the deep voice, whilst he observed that it remained near the base of the tongue in the shrill notes.

Moeller has remarked that the intercrico-thyroidae space diminished during the passage from chest to head register, thus confirming the informations given by the laryngograph.

Frœschel has studied the movements of the soft palate by covering it over with a bismuth paste so as to reinforce the shadows, showing clearly, as I have been able to observe myself, that this organ, in certain cases of which mention will be made in due course, rose and shut the communication between the mouth and the nose.

Mouldings of the mouth. — When one wishes to obtain the shape of the buccal cavity, one takes the moulding of it by means of the same contrivances as those employed by the dentists. To this effect, one uses *stents composition* which has the propriety of softening under the action of heat and hardening quickly when the temperature is normal. This substance is plunged into hot water, so that it should become sufficiently malleable; thus it is introduced as far as possible inside the buccal cavity, previously disposed according to the shape which it takes in the production of the studied vowel. To harden the piece rapidly a cold water current is sent inside the mouth, then one lets the moulding fall into a basin containing also cold water.

To obtain a counter-moulding representing the normal cavity, one applies on a plaster cake[1] the lower part of the impress which has been previously spread lightly over with oil. When the plaster has set, a moulding of the upper part of the stents is taken in the same way. By putting together the two faces of this counter-moulding, one has the moulding of the buccal cavity as it is disposed for the uttered vowel. But these mouldings are not of a great utility in the study with which we are dealing.

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[1] The plaster is tempered in lukewarm water to which are added about 4 grammes of sulphate of potash per glass. It is applied on the impress when it forms a sufficiently thick mass, and kept there for a few minutes till the mass has well taken The latter is then plunged into cold water, so that it should get absolutely hard.

Artificial palate. — The function of this apparatus is to indicate the position of the tongue in the articulation; it can therefore be useful in certain cases for the tuition of articulation.

J. Oacley-Coles, in 1871, was the first to have the idea of studying the movements of the tongue with respect to the palate. He made use to this effect of a mixture of flour and gummed-water. Later, in 1882, *Norman W. Kingsley* took a plaster moulding of the soft palate and made a stamping in black vulcanite. By covering this artificial palate over with chalk wetted with alcohol, he was able to proceed with his experiments.

An artificial palate can be quickly made with a filter paper dipped in water, on which is applied a mastic composed of chalk in powder and of seccotine, and covered over with an other sheet of wet

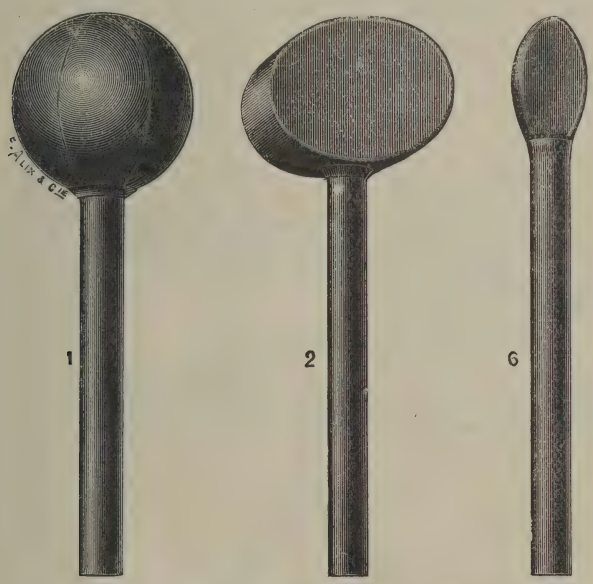

Figure 64.
Exploring bulb.

filter paper. One stamps it well with the fingers or with a pencil; one puts it to dry for twelve hours, before cutting out with scissors the contour of the teeth; then, one spreads over it a solution of rubber and one varnishes the piece. But a palate thus made cannot make a long service (*Rousselot*).

Another rather convenient way of obtaining a palate is to cover the stents mould or the plaster counter-moulding over with oil, so as to prevent any adhesion; afterwards, with a brush several coats of a solution saturated with celluloid dissolved in acetone are put

on, being careful therewhile to wait a few minutes between each coat until the desication has taken place. More consistency is given to it by applying a layer of absorbent cotton wool which is carefully made to adhere by finger pressure, then again one or two coats dissolved celluloid are put on, one dries without rubbing but by means of slight pressures repeated from time to time, and when the apparatus is quite dry one throws it in cold water and, finally, puts it to dry.

Before use, it is sprinkled over with talc. Then, it is placed in the mouth of the subject on which the experiment is being made, the precaution being taken of making the tongue rest on the floor of the mouth without letting it touching the roof. The patient is asked to articulate, then the palate is taken away and marked at the place where it has been touched by the tongue. To make the reading of the contact points easier, it is best to bore a series of holes in the artificial palate, so that they may serve as marks.

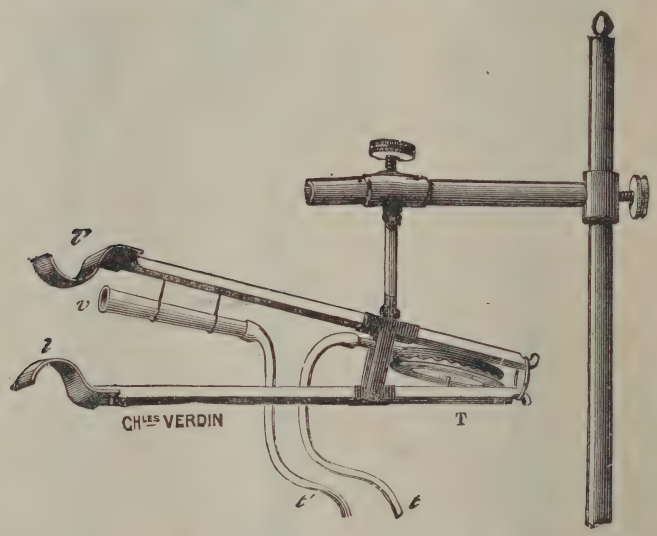

Figure 65. — Olives.
Rosapelly's explorer of the movements of the lips.

To determine the position of the tongue, an impression is taken with a band of stents and compared with the moulding in the hollow of the soft palate.

Exploring bulbs. — By means of the exploring bulb, which is made of india-rubber and varies in shape, one is able to ascertain the various degrees of pressure exercised by the tongue against the roof of the mouth (Fig. 64).

This bulb is joined to a recording drum, and marks on the registering cylinder (Fig. 12) the movements of pressure of the tongue upon the palate.

These bulbs, as well as *Rosapelly*'s explorer or the explorer of Abbé *Rousselot*, are also made use of in the study of the movements of the lips.

Olives (Fig. 66) can be adapted to the nostrils and joined to the recording capsules, so as to register the movements of the soft palate and the nasal vibrations, as well as the passage of the air through the nasal cavities.

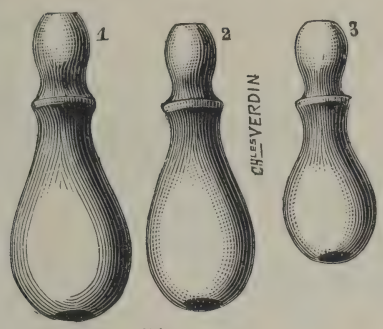

Figure 66.

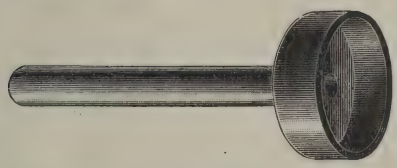

Figure 67.
Exploring capsules for the vibrations of the larynx.

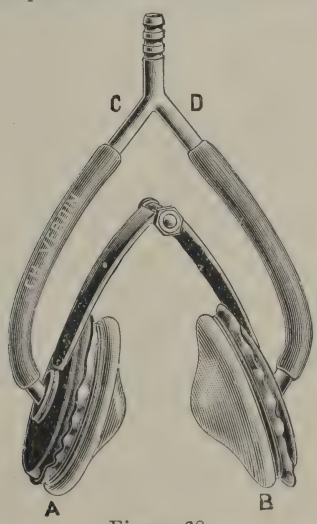

Figure 68.
Zund-Burguet's laryngograph with double cap.

There exists also a series of apparatus like the exploring capsules for the vibrations of the larynx (Fig. 67), the laryngograph with double cap (Fig. 68), the explorer of the movements of the larynx (Fig. 69) of which use is made in the study of the displacement of the larynx during the emission or articulation of sounds;

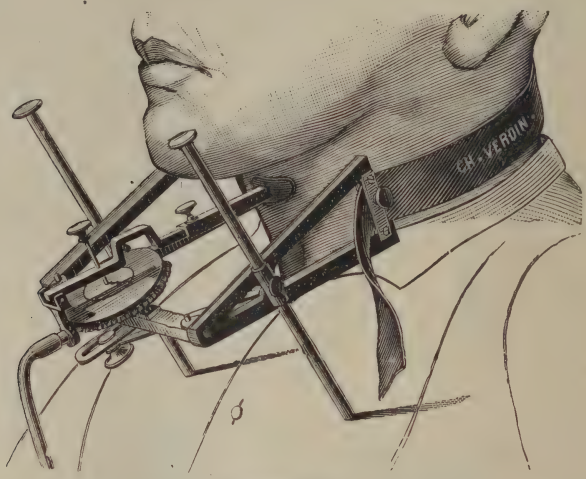

Figure 69.
Explorer of the raising and falling movements of the larynx.

Zwaardemaker's apparatus serves to register the movements of the lower jaw; finally other various instruments are the means of appreciating the modifications of the tongue and the lips, while the production of tones takes place.

CHAPTER VI.

FORMATION OF THE VOICE.

Cavities through which the sound passes. — I have previously explained how the air rejected from the lung came to form the sound in the ventricles, thanks to *Lootens*'s vortex.

It arrives further in a first cavity which is the upper part of the larynx, *laryngeal aditus*, and is included between the ventricular bands, the aryteno-epiglottic folds and the lower side of the lid (Fig. 62).

Owing to its mobility the latter is able to come down at the back over the larynx which it covers more or less, thus modifyring the capacity of this organ. It is easy to understand that when the lid is lowered, the tracheal air is obliged to follow the direction imposed through this lowering; it is then directed more or less obliquely towards the posterior part of the *buccal pharynx* which forms the second cavity in which the sound spreads itself.

This cavity is limited at the bottom by the lid, at the back by the spine and the muscles which cover it over, in front by the horizontal portion of the tongue and by the pillars and the soft palate (Fig. 1, *B*).

Thanks to the muscular walls by which it is formed, the pharynx can easily change shape during the phonation, either shortening longitudinally or diminishing transversally of volume through the action of the muscles inserted on the base of the skull, on the larynx, the hyoid bone and the lower maxillar, and also, according to its antero-posterior axis, through the play of the base of the tongue. The movement of contraction of the pharynx produces a decrease in its diameter, at the same time as a raising of the larynx and of the soft palate, during the emission of the shrill notes. On the contrary, in the deep notes, the pharynx lengthens and increases in volume, whilst the larynx and the soft palate are drawn down.

The *nasal cavity*, formed by the nasal pharynx and the nasal chambers, constitutes the third cavity.

When the soft palate is not raised (Fig. 1, *A*) the *buccal pharynx* communicates widely with the nasal pharynx. The nasal cavity is nearly entirely formed by bony walls; it is membranous only in its postero-inferior portion, represented by the soft palate and the pillars of the palate.

Finally, a fourth and last cavity, *buccal cavity,* which is placed in front of the buccal pharynx, receives the sound before it comes out through the lips. This cavity is of supremely varying capacity, first of all by reason of the dimensions of its entrance opening on the level of the soft palate, and of its exit opening on the level of the lips, and also owing to the various positions taken by the tongue which can flatten itself against the floor of the mouth, rise against the roof, or apply itself behind on the posterior wall of the pharynx. In its rising movements towards the roof of the mouth, the tongue can even divide the buccal cavity into two other ones, which vary themselves in size according to the emission of the vowels, as will be indicated further.

Sphincters. — Thus, the aerial duct is formed by a series of cavities, which vary in capacity thanks to certain narrowing processes which occur on the passage of the air.

A first narrowing, or sphincter, is placed between the wind-pipe and the vocal cords : this is the *glottis,* formed by the vocal cords which approximate more or less, so as to give passage just to the quantity of air necessary for the formation of the tone in the ventricles.

A second narrowing : *aryteno-epiglottic sphincter,* is formed by the aryteno-epiglottic folds and separates the laryngeal aditus from the pharynx, contributing, as I have already said, to modify the direction of the sound when it comes out of the larynx.

The *velo-palatal sphincter,* which corresponds to the soft palate and its pillars, and also to the base of the tongue, is charged to distribute the air which comes out of the pharynx, either in the mouth or in the nasal cavities, according as it is shut or open, thus increasing or diminishing the capacity of the buccal and pharyngeal cavities.

A fourth sphincter, *linguo-palatal sphincter,* situated between the horizontal part of the tongue and the palate, divides the buccal cavity into two parts : one anterior and the other posterior, of varying capacity, according to the uttered vowel.

Finally, a last narrowing, *labial sphincter,* has for function to let the sound escape outside after it has undergone the transformations necessary for the production of voice. It is constituted by the orbicular of the lips.

All these sphincters are of capital importance in the formation of the voice.

Formation of vowels and consonants. — It is in the mouth that the sound receives the characteristic impress of the vowels and the consonants, so that the voice be formed.

Vowels. — *Helmholtz*, as regards the vowels, admits the following classification for which the disposition given to the mouth has been taken as basis.

É · · · · · *I*
A · · · · *EU* · · · · · *U*
O · · · · · *OU*

The vowel *a*, to which corresponds a funnel-shaped opening of the mouth, is the starting point of the series.

For *a*, the tongue rests on the buccal floor, the air comes out freely without encountering any obstacles. *A* is called a medial vowel because, when uttering it, the tongue occupies in the mouth an intermediary medial position between the anterior vowels *i*, *u* and the posterior vowel *ou*.

For *é*, the tongue is placed in an intermediary position between the anterior vowels and the medial vowels *a;* and for *o*, it occupies an intermediary position between the vowel *a* and the posterior vowel *ou*.

The tongue keeps close to the incisive teeth during the emission of *é*, *i*, *u*, but it draws back progressively for *o* and *ou;* thus the tip of the tongue retires in proportion as one utters *ou*, *o*, *a*, *é*, *i*.

There are also variations of distance from the tongue to the palate; the point of articulation rises and advances progressively for *a*, *é*, *i* and rises and moves back in the same manner for *a*, *o* and *ou*.

In the same way also the labial orifice widens for *i* and for *é*, diminishes for *a* and *o*, and narrows up for *u;* the diameter of the buccal aperture becomes smaller successively for *a*, *e*, *o*, *i*, *u* and *ou*.

The cheeks follow the movements of lips and jaws, sinking in when these are drawn apart or, on the contrary, becoming rounder when the commissures are drawn backward.

For the production of the vowels, the jaws do not always follow a movement parallel with the movement of the lips, for the opening of the maxillars increases progressively for *i*, *u*, *e*, *o* and *a*.

The three groups of vowels are thus devided according to the disposition of the mouth.

First group : the lips are stretched horizontally, the tongue rests against the lower incisive teeth : *i*, *é*, *in*, *ê*.

Second group : the lips advance forcibly and approximate in

form of a channel, the tip of the tongue rests behind the lower incisive teeth, its centre being raised towards the palate : *u, eu, un* and *e*.

Third group : the lips advance again channel-shaped, the tip of the tongue makes a movement backwards : *ou, ô, on, o*.

Lastly, *a* completes the first group of which it borrows the form, but without the advancement and the withdrawal of the lips.

Donders and *Rud. Koenig*, like *Helmholtz*, maintain that for the formation of the vowels the capacity of the buccal resonator must not vary and its opening has to be fixed.

But *Marichelle*, in his book on *speech according to the record of the phonograph*, has shown that these conditions were not indispensable. Thus *ou*, which corresponds to the maximum capacity of the resonator and the minimum opening of the lips, according to *Helmholtz*'s theory, can be easily prounounced if one fills up with wax all the hollows of the palate, leaving only a very narrow passage between the tongue and this artificial palate. It is even so for *o*, etc... hence one is able to conclude that the capacity of the buccal resonator has no characteristic influence on the timbre of the vowels.

Likewise, if to utter *i* and *é*, the labial commissures must be stretched apart, whilst for the other vowels the lips must be advanced or drawn back, one can nevertheless obtain with some practice the two vowels *ou* and *i* by opening perceptibly the lips, whilst the open sounds *o* and *é* can be delivered with a much smaller labial orifice than previously, as may be ascertained by pronouncing rapidly « *pioupiou* », for the lips keep joined during the emission of *i*. Therefore the dimension of the labial orifice gives only a vague and instable general indication.

It may be equally observed that, as regards the opening of the jaws, the latter's angle varies for the same vowel according to the tone and the rapidity of the utterance, and also to the associated elements. For instance, if one calls out loudly the word « *Emile* » one will notice that *i* will be more opened than *é*. Consequently the opening of the maxillars does not characterize sufficiently the vocal sounds.

Finally, the displacements of the tongue forward and backward do not give any precise and essential information regarding the timbre of the vowels. If one observes a person speaking normally, one will be able to remark that in ordinary conversation the tongue does not accomplish any movement in totality. All the vowels can be pronounced without the tongue being drawn back a quarter of a line : *titoutu, tétoteta*, etc. (*Marichelle*.)

On the other hand the experimenters are far from agreeing on the subject of the vocables which some believe to be exact harmonics of the laryngeal sound, and others, harmonics independent from this sound.

Let us consider these vocables which correspond to the different vowels after *Helmholtz* and *R. Koenig*.

ou = *Fa*^{2} (*Helmholtz*) *Si*♭^{2} (*Koenig*)
o = *Si*♭^{3}
a = *Si*♭^{4}
é = *Si*♭^{5}
i = *Ré*^{6} (*Helmholtz*) *Si*♭^{6} (*Koenig*).

If one takes into consideration that the timbres of each vowel differ according to the idioms and the individuals, one will realize what number of vocables can exist between *Fa*^{2} and *Si*♭^{6}, limit of the vocables indicated in the above table.

As the change in the form of the mouth determines also a change in the vowels, that is a change of the reinforced laryngeal tone — the vowel being only a reinforced laryngeal tone — it is necessary that the larynx should utter all the vocables which can be utilized by the mouth.

As *A. Guillemin* has observed, if a woman singer wishes to deliver the vowel *o* on the note *La*^{3} she must make her larynx render at the same time as a smart *La*^{3}, a very discreet *Si*♭^{3}, so that the mouth may reinforce this latter note which is the vocable of *o*. Likewise if the mouth is given the shape corresponding to *ou* whose vocable is *Fa*^{2}, the singer will have to find also a *Fa*^{2} in the complex tone uttered by the larynx singing *La*^{3}.

The same contradiction may be observed in the case of the larynx of a bass capable to give *Ut*^{1}. While singing this note, which must be accompanied by all the vocables, the artist will have to render at the same time all the tones included from *Ut*^{1} to *Si*♭^{6}!

All the foregoing instances go to prove clearly that one must leave aside the theory of the characteristic tones of the mouth and the corresponding reinforced tones, and replace the buccal resonance by a more plausible explanation.

Besides, *Helmholtz*'s theory cannot explain whispering, all the more so as it is possible to produce whispered tones in drawing in air. The breath noise in whispering comes from the buccal orifice.

Similarly in buccal whistling which requires less aerial pressure than whispering, it is again the labial aperture which is the cause of the sound, whether one whistles while inhaling or while expiring.

It is well known that the whistling tones become shriller if one breathes deeper or if one narrows the buccal orifice, or also if one diminishes the cavity of the mouth, by means of movements of the tongue which is lowered or drawn back in deep tones, in accordance with the laws of aero-dynamics.

Instead of asserting positively that the *larynx* gives initially an infinitely complex sonorous mixture, one must say that it *creates only the tone of the voice and that the upper-laryngeal cavity does not reinforce but engenders the sounds.*

The surgery of the larynx shows us futhermore that the vowel is not a reinforced laryngeal tone, for if one suppresses the larynx and joins directly the wind-pipe to the skin of the neck, the sound comes directly outside, without passing through the pharynx and the mouth. But let us take an india-rubber tube containing simply a membrane of similar nature, stretched in such a way that it leaves an opening on each of its edges, if we place this tube at the outlet of the wind-pipe, on the level of the neck, and introduce the other end in the mouth, one will be surprised to hear the air, which goes through this membranous reed, enable the patient to hold a conversation in such a way that anybody who did not see him would believe that a normal person was speaking. Still better, we have heard several individuals who had undergone this operation deliver a few notes of music!

Is not this instance the best proof that, in the production of the characteristic vocables of the vowels, the buccal cavity does not act as resonator, in other words, that it does not inflate a fixed tone but is the generator which creates the tone necessary for the obtainment of a determined timbre.

The buccal and pharyngeal cavities can vary in shape and in dimensions; consequently they produce a series of extremely sundry tones most finely diversified in timbre, intensity and pitch, without requiring that the larynx should furnish them with anything else than the air current.

If the air current is aphonous, it produces only whispering or whistling noises.

When the air current is sonorous, it engenders in the cavities through which it passes new tones which superpose themselves to the ventricular tones, creating the pitch of the tone.

It is owing to the play of the vortex, of the air movements or of *Lootens's cyclones* always that the tone, which is needed for the obtainment of a particular timbre, is produced.

I have spoken previously of the cavities traversed by the sound, and of the narrowings, or sphincters, which form themselves on their course. Let me specify certain bearings of these organs in connection the ones with the others, so as to be able to understand more clearly the mechanism of the formation of the vowels. I bear in mind that in the mouth the palate, being bony, cannot undergo any modification in shape or position; but such is not the case for the soft palate which comes immediately after, for, hanging vertically from the mouth, it can move easily by reason of its mem-

branous constitution, and be carried towards the back-cavity of the nasal chambers, shutting them more or less completely according to the emission of the vowels.

The roof of the palate and the soft palate constitute the upper portion of the buccal channel, the lower portion of which is formed by the horizontal part of the tongue which rests on the floor of the mouth, the lateral wall being built by the lips. The tongue is continuated at the back, inside the pharynx, by its vertical portion called *base of the tongue,* thus forming the anterior wall of the buccal pharynx.

The base of the tongue is attached upon the hyoid bone.

The hyoid bone, which is situated in the front part of the neck, between the horizontal branch of the lower maxillar and the larynx, is fixed to no osseous tissue whatever, hence its great mobility. Some of the muscles of the base of the skull are inserted upon this bone, and complete thus the system of suspension.

To its lower part are attached muscles which leave from the larynx and from different bones constituting the thorax, thus rendering the movements of the tongue binding upon those of the larynx. Therefore when the tip of the tongue is carried forward, behind the incisive teeth for instance, the base of the tongue follows the raising movement, drawing the hyoid bone and the larynx. In the movement of deglutition, the base of the tongue is carried backward, drawing down, as it falls, the hyoid bone and the larynx.

With the exception of *a,* all the vowels are formed on the level of a more or less close approximation of the tongue with the roof of the mouth, this contraction being called, as aforesaid, palato-lingual sphincter. The name of *generative orifice of the vowel* is given to the opening formed by the walls of this sphincter.

Each vowel is descried through the position occupied by the generative orifice along the buccal channel, this orifice being variable in size owing to the more or less close approximation with the palate. This opening is rated, not according to the maxillar angle or the labial orifice, but to the degree of narrowing formed by the tongue and the palatal roof : this, I repeat, in answer to those who have contended that the vowel was submitted to the influence of the opening of the mouth, neglecting therewhile the importance of the tongue.

How is it possible not to conceive the part taken by this organ in the formation of the vocables, when one knows that by pressing any kind of object on its back part, the pronunciation of the vowels becomes difficult? The sounds which come out under these conditions are unintelligible. The case is the same when an illness provokes the swelling of the tongue or of the tonsils, thus preventing the working of the former which has lost its mobility.

Most of the defects in pronunciation come from a wrong position of the tongue. And when this organ has been amputated the language becomes incomprehensible.

In the formation of the vowels, one notices that the stricture of the palato-lingual channel, otherwise named generative orifice of the tone, is very narrow for *i*; the aperture widens for *e*, *ê*, *u*, *ou*, *a*, attaining its maximum opening for the latter vowel.

The generative orifice is drawn further and further away from the anterior part of the palate, which it had previously occupied for *i* and *u*, and is carried more and more to the back for the other vowels, as may be verified (Fig. 70).

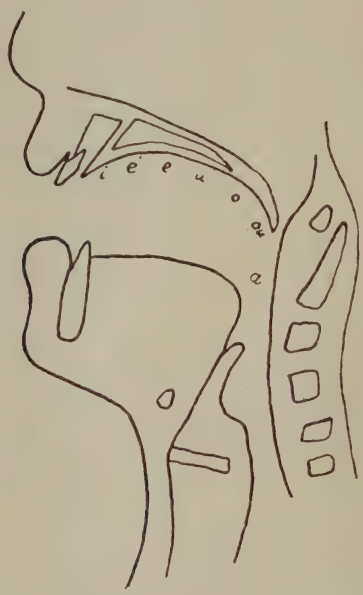

Figure 70.
Section of the palato-lingual channel showing the position of the generative orifice for the different vowels.

In proportion as the generative orifice of the vowel moves backwards, and as the tongue is brought away from the palatal roof, the buccal cavity widens from front to back, whilst the pharyngeal cavity narrows parallelly, owing to the withdrawal of the tongue and the approximation of its base towards the posterior wall of the pharynx.

I have previously made an exception for the formation of the vowel *a*, as the buccal narrowing required by the other vowels does not take place here. Nervertheless in the emission of *a*, the posterior wall of the pharynx comes slightly forward and the base of the

tongue is drawn backward, thus narrowing the passage of the sound in the back of the mouth.

By reason of the close connections existing between the tongue and the larynx, modifications in the position of the organ take place in the pharynx and vary with each vowel.

Thus for *ou*, which is formed in the posterior part of the buccal cavity, the tongue is not pulled forwards, consequently the hyoid bone does not rise in the neck, and the larynx keeps lowered. The base of the tongue, curved backwards, comes near the posterior wall of the pharynx, therefore the latter organ contracts according to its antero-posterior axis (Fig. 71). The lid falls backward on the larynx.

For *i*, on the contrary the tip of the tongue hits against the incisive teeth, carrying in its movement its own base, the hyoid bone and the larynx. The base of the tongue draws away from the posterior wall of the pharynx, thus provoking widening of this cavity, according to its antero-posterior axis (Fig. 72). The lid is raised. Let us remark also that for *i*, the raising of the tongue against the front wall of the palatal roof divides the mouth in two parts : a small anterior cavity which spreads from the teeth to the generative orifice of the vowel, and a larger posterior cavity which extends till the pharynx.

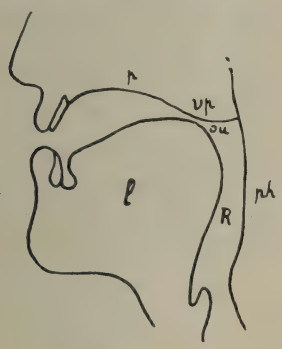

Figure 71. — Vowel *ou*.
l tongue. — *p* palatal roof. — *v p* soft palate. — *p h* posterior wall of the pharynx. — *R* contracted resonator. — *ou* generative orifice.

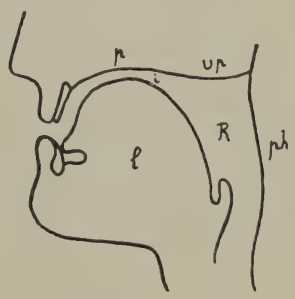

Figure 72. — Vowel *i*.
l tongue. — *p* palatal roof. — *v p* soft palate. — *p h* posterior wall of the pharynx. — *R* enlarged resonator. — *ou* generative orifice.

It is a different matter for *ou*, owing to the position behind the generative orifice, the front part is much larger than the back one.

The soft palate plays also a part in the formation of the vowels. It changes of position, rises so as to attain its maximum in the emission of *i*, and falls more and more respectively for *ou*, *o*, *é*, *e*, *u*, coming back for the latter vowel to its vertical position in the throat (Figs. 73 and 74).

The rising of the soft palate is due to the increase of the air pressure inside the pharynx; the pressure grows stronger from *a* to *i*, by reason of the progressive narrowing of the generative orifice of the tone.

In the nasal sounds *in, on, en, an,* the soft palate is maintained completely down, it lets the sound come thus partly in the nasal pharynx and in the nasal chambers, whilst it shuts more or less these cavities for the other vowels, in the production of which most of the air comes out through the mouth (Fig. 75).

Figure 73.
Position of the soft palate raised when *i* is uttered.

Figure 74.
Position of the soft palate somewhat lowered when *a* is uttered.

1 uvula. — 2 posterior pillars of the soft palate. — 3 anterior pillars. — 4 tongue.

It is therefore only through neighbouring concussion that the vibrations of the buccal pharynx are propagated to the air of the nasal resonator, as there is no direct communication between these two parts, in the pronunciation of *i*, for instance.

Figure 75.
Position of the soft palate in the production of nasal tones.

This shows the impossibility of placing the sound in the mask, in the nose, between the eyes, expressions so often used in quack language, or of demanding that the singer should hold the soft

palate constantly raised or lowered, the position of this organ varying with each vowel. If the Italians sing oftener with the soft palate raised, the reason is that the vowel *i* recurs constantly in the Italian language; but no universal law should be drawn from this fact.

Consonants. — The consonants have been divided into two groups : *explosive* and *continuous*, according as they are uttered by means of a sudden alteration of the position of the parts of the mouth which let the air escape, or as they are engendered without stoppage in the breath which accompanies their articulation.

The explosive consonants, as confirmed by the phonetic, are : *b, p, d, t, g, k, c;* the continuous are : *y, f, z, s, j, l, r, m, n.*

In this matter, the artificial palate renders great services, as it enables the position of the tongue to be ascertained in the production of these consonants.

For instance, the tongue rests strongly against the upper incisive teeth for *t*; it touches the aforesaid teeth for *p*; it hits against the lower incisive teeth for *b* and for *m;* and touches the sockets of the latter teeth for *d* and *n*. For *r*, the tongue having to vibrate does not touch the palate; and for *l*, it rises and curves backwards without coming in front into touch with the palate. For *j* and *ch* the tip of the tongue retires backwards, and the palatal contact is somewhat more accentuated for *ch* than for *j*.

The tip of the tongue presses against the lower incisive teeth for *s* and *z*; in this instance there is no palatal contact, the back of the tongue projects backwards.

The tip of the tongue keeps also against the lower teeth whilst the back rises progressively for *v*, *g* and *k*.

The lips take a particular shape in the articulation of each consonant; they come closer together for *t* and *d* than for *k* and *g*, and for *d, n, r* than for *l*. They stretch out for *ch* and *j*, and draw in for *s* and *z*.

The jaws widen apart for the labials, and approximate progressively for *k, g, p, l, r, n, t, s*.

The consonants are generally classed according to their region of articulation, that is to the spot where the sound meets the obstacle which engenders them.

The guttural consonants are formed on the level of the soft palate which stops the air current by leaning against the tongue, these are : *q, k, h, j*.

The lingual consonants are formed on the level of the upper dental arcade and of front part both of the palatal roof and of the tongue, which rests by its edges against a more or less wide extent of the dental arcade, so as to produce these consonants which are : *s, z, n, d, t, r, l, g, ch* and *j*.

The labial consonants take birth on the level of the aperture of the lips which, pressed against each other, separate themselves to let the sound pass, these are : *p, b, l, m.*

Some authors have classified as dental, the consonants *n, d, t* (lingual dental consonants) and *v* and *f* (labial dental consonants).

Mr. *Marichelle* has summarized in the following table the localization and the closing of the generative orifice for the vowels and the consonants [1].

The localizations, as may be seen below, take place in 6 different regions (read the table vertically).

Localization → Posterior regions						
Closing ↑	1	2	3	4	5	6
I	*P* *F CH*	*T* *S*	*CH*		*C*	
II	*B* *V J*	*D* *Z*	*J*		*G*	
III	*M*	*N*	*L, R*	*Y* *GN* . . . >		
IV	*U, OU*			*I, U*	*OU*	
V	*EU, AU*			*É, EU*	*AU*	
VI	*E, O* *UN, ON*			*É E* *IN UN*	*O* *ON*	*A* *AN*

Figure 76.
Classification table of the elements of speech, according to the notions of closing and localization.

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[1] One calls localization, the position occupied by the back of the tongue, in respect to the roof of the buccal cavity (palate and soft palate) and closing, the degree of resistance opposed to the exit of the sonorous column by the obstacle, across which it comes in the aerial tube which prolongs the pharynx until the outside.

1st region.	—	*Lips : P, B, M—U, EU, E, UN—F, V, Ch, J—OU, AU, O, ON*[1].
2nd »		*Tip of the tongue and teeth : T, D, S, Z, N.*
3rd »		*Front part of the palate and tip of the tongue : CH, J, L, R.*
4th »		*Back part of the palate and back of the tongue : GN, Y—I, U—É, EU—Ê, E, IN, UN.*
5th »		*Back part of the palate and base of the tongue : C, G—OU, AU, O, ON.*
6th »		*Posterior wall of the larynx, base of the tongue and soft palate : A, AN.*

The closing of the generative orifice increases from bottom to *top* (read the above table horizontally). The widest opening corresponds to the horizontal line VI, and the complete occlusion to the horizontal line I.

I.	The occlusion	is	complete	for		*P, T, C—F, S, CH.*
II.	»	»	is less	»	»	*B, N, G—V, Z, J.*
III.	»	»	»	»	»	*M, N, GN, L, R, Y.*
IV.	»	»	»	»	»	*OU, I, U* (shut vowels).
V.	»	»	»	»	»	*AU, É, EU* (half shut vowels).
VI.	»	»	»	»	»	*A, O, Ê, E—AN, ON, IN, UN* (open vowels).

It is worthy of notice that in the case of elements belonging to the same class of localization, such as *GN, Y, I, Ê, E, IN,* for instance, when compared between themselves, or of a given element pronounced under different conditions, the region of the linguo-palatal orifice is so much the more further away that the widening apart of the maxillars is more considerable. Thus the region of *Ê* is generally somewhat further away than the one of *I*, and for the latter element the linguo-palatal orifice is carried forward or backward, according as one raises or lowers the maxillar.

Let us remark also that the words « closing » and « opening » do not apply to the stretching apart of the maxillars or of the lips, but to the orifices which must be traversed by the sound in the channel which extends from the upper-lryngeal cavity to the nostrils and the lips, after having run through the pharynx and the mouth. It is therefore essential to know that it is solely the power of the obstacle which, by opposing itself to the course of the breath,

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[1] The elements with double orifice, viz. labial orifice and linguo-palatal orifice (*OU, AU, O, ON, U, EU, E, UN*) figure necessarily in two different columns of the articulation.

gradually diminishes the intensity of the voice[1]. Mr. *Marichelle* adds : this is the reason why we have placed the nasals *M, N, GN,* in the third class of closing and not in the first, though the production of these consonants necessitates the total occlusion of the mouth; in this particular case, the closing of the tube added to the larynx (upper part of the larynx, pharynx, mouth and nasal chambers) is only apparent, for the partial lowering of the soft palate lets the voice pass through the nasal chambers.

We may add too that the soft palate rises progressively from the 6th class, which is the closing class, to the first one (see p. 99, Figs. 72, 73, 74).

The vibrations of the voice can be felt with the hand, as may be ascertained by laying it on the chest or on the top of the head Thus, one observes that the intensity of the concussion increases at the chest and decreases at the top of the head, proportonally to the opening of the sound's generative orifice : the vibrations being very strong for the shut vowels *ou, u, i,* less strong for the half shut vowels *au, é, eu* and weak for the open vowels *a, o, ê, e,* whilst the resonance of the chest is also accentuated proportionally to the opening of the generative orifice, being very strong for *a* and very weak for *i*.

The vibrations of the chest, very strong in the 6th class of closing, diminish from class to class till the first class is reached, then they cease entirely.

The 6th class vibrates nearly exclusively the chest, whilst in the opposite extremity of the table, the 2nd class sounds practically only the head.

If one seizes between the fingers the upper part of the larynx, above the Adam's-apple, one observes that the gradation, as regards the vowels, is the same here as when the top of the head is taken into consideration.

This transmission of the vibrations has been verified through Stefanini's experiences, in the course of studies on the flames of Marbe.

Consonants and vowels are descried by a change in the opening of the buccal sphincter (labial and linguo-palatal orifice); this opening increases the resistance which the air, sent from the lung,

---

[1] Thus for the vowel *i*, which requires a close approximation between the tongue and the roof of the mouth, the degree of resistance, which is opposed to the coming out of the sonorous column, is more considerable than for *é* and for *ê* which demand a progressively greater drawing apart of the tongue from the palatal roof.

Let us observe also that if the linguo-palatal channel, which corresponds to *i*, becomes narrower, the vowel *y* is obtained; on the contrary, if it widens progressively the vowels uttered are *é* and *ê*. In fact, *é* and *ê* are only like a more open *i*.

makes in the mouth when trying to come out; this resistance decreases as from the consonant to the vowel, thus provoking an augmentation of the vocal intensity.

From what preceeds, one is able to see in what close connection stand the laws which regulate the progression of the generative orifice's closing, of the sonorous intensity, of the inner pressure, of the outer vibratory movement and of the raising of the soft palate.

The voice is measured by the degree of the generative orifice; purely sonorous when it encounters no serious obstacle (*a*, *o*, *ê*), the voice thins insensibly in traversing the more and more narrow passages which tend to stop it in the mouth; already, if no attention is being paid, the vowels *ou*, *i* and *u* are accompanied by a slight puffing; one degree more and the laryngeal sound is tinged with the buccal noise (*l*, *r*, *y*); the voice is soon reduced to the condition of a single murmur (*v*, *z*, *j*, *b*, *d*, *g*); lastly its disappears entirely by reason of the total occlusion of the mouth (*p*, *t*, *c*).

It may be said that the pure consonant is the complete occlusion of the mouth, whilst the pure vowel is the full voice, traversing the additional tube of the larynx, sufficiently open in all its regions (*Marichelle*).

Mechanism of the formation of the vowels and of the consonants [1].

A.

The mouth is widely open, showing the upper incisive teeth. The tongue rests upon the floor of the mouth, its tip behind the lower incisive teeth; the soft palate is raised so as to prevent the air from passing in the cavities of the mouth. The pillars of the soft palate are close to the median line (Fig. 77).

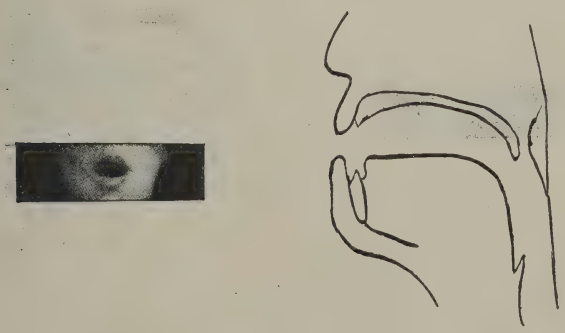


Figure 77. — *A*.

[1] For each letter I am giving the photograph of the mouth, the position of the organs contained in the buccal cavity and artificial palate. The touch of the tongue on the palate is represented by the shadowed part.

O.

The mouth is less open than for *A*. The opening is rounded so as to produce the aspect of an *O*. The anterior part of the tongue is flattened, the posterior part is more raised towards the roof than for *A* (Fig. 78).

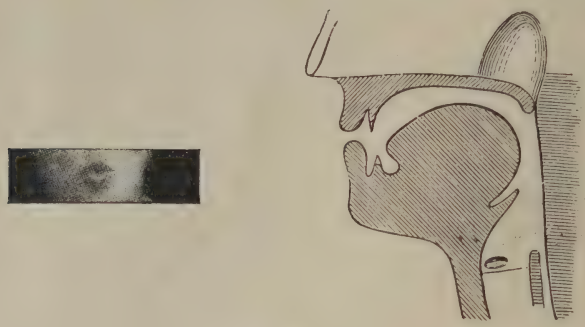


Figure 78. — *O.*

OU.

The mouth orifice is rather narrow and rounded. The lips, which are close together, advance, away from the teeth. The tongue is drawn further back and, at the same time, rises towards the posterior part of the palate. The soft palate is kept raised. The larynx occupies the lowest position it can take in the neck (Fig. 79).

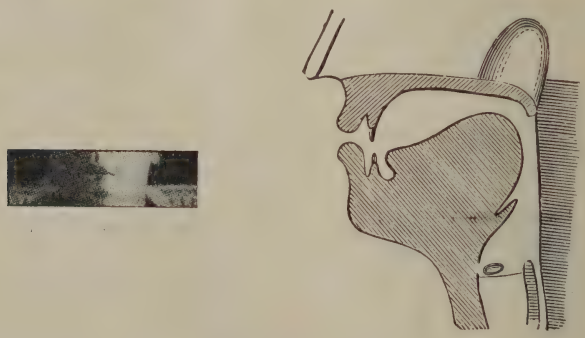


Figure 79. — *OU.*

EU, U.
E, I.

One passes from *A* to the other series of vowels by bringing the tip of the tongue nearer to the palate, and by modifying the opening

of the mouth through the disposition of the lips. Thus, two cavities are formed in the mouth : one, anterior, is narrower, and the other, posterior, larger.

The mouth, says *Gavarret*, takes the shape of a bottle with neck, directed forward, ending at the labial orifice, and with body terminating at the pharynx.

This division of the mouth into two cavities is important, in respect to the play of the vortex which gives birth to the vowels.

For *EU* and *U*, the lips approximate laterally, and form a tube which prolongs in front of the anterior cavity of the mouth assimilated to the neck of a bottle; and for *E* and *I* the lips, drawn back, give to the buccal orifice the shape of a narrow horizontal chink.

EU.

The mouth is half opened. The lips are disposed as for *O*. The tongue, bearing against the lower incisive teeth, is bulged in its middle part (Fig. 80).

Figure 80. — *EU.*

U.

The lips are disposed as for *OU*, but are slightly set apart. The tongue is in contact with the lower incisives, but do not touch the roof otherwise than in its lateral and posterior part (Fig. 81).

Figure 81. — *U.*

E.

The mouth is less open than for *O* and the labial commissures are apart. The maxillars are separated by a small interval. The tip of the tongue, behind the lower incisive teeth, is bulged and touches the lateral parts of the roof, on the level of the big molar teeth. The tongue rises a few millimetres in passing from *A* to *E* (Fig. 82).

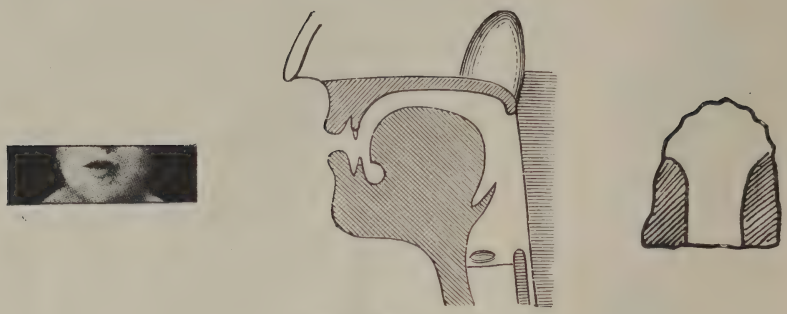


Figure 82. — *E.*

I.

The buccal cavity is reduced to its minimum. The lower and upper teeth are very near each other, but do not touch. The labial commissures are stretched far apart. The tongue, set against the lower incisive teeth, touches the roof with its back, thus coming nearer to the soft palate. The palatal contact is increased in breadth and in length. The soft palate, which is raised, rests against the back wall of the pharynx, so as to shut the cavities of the nose. Both larynx and pharynx are situated accordingly to their maximum of height. The air passes between the tongue and the roof in producing a slight noise of friction (Fig. 83).

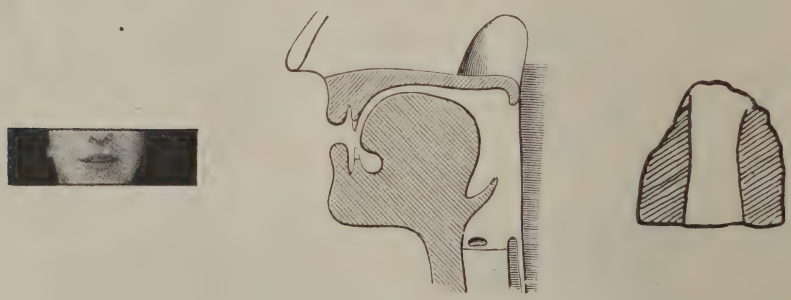


Figure 83. — *I.*

AN, OU, IN, UN.

For those nasal vowels, the soft palate is lowered so as to let the sound pass in the cavities of the nose (see Fig. 75); thus is obtained a nasal resonance.

AN is *a* with a nasal resonance.
ON is *o* » » »
IN is *è* » » »
UN is *eu* » » »

P.

The lips are pressed together. The commissures are stretched apart. The soft palate is raised. The tip of the tongue touches lightly the upper incive teeth, without the tongue coming into contact with the roof. The lips, in separating violently from each other under the influence of the expired air current, produce an explosion (hence the name of explosive consonant). The wings of the nose do not vibrate (Fig. 84).

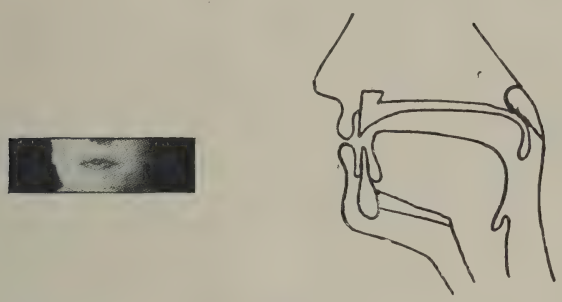


Figure 84. — *P.*

B.

The play of the organs is the same as for *P*, with the difference that, with a slight lowering of the upper-hyoidal region, a laryngeal rustling noise is produced which can be perceived by placing the hand on the level of the Adam's-apple (Fig. 85).

Figure 85. — *B.*

M.

This nasal consonant is due, like *P* and *B*, to the occlusion of the lips, but the soft palate is lowered, so that the air current may pass at the same time through the mouth and through the nasal chambers. The wings of the nose are set into vibration when the explosion of the lips takes place, the latter giving way throughout their whole expanse (Fig. 86).

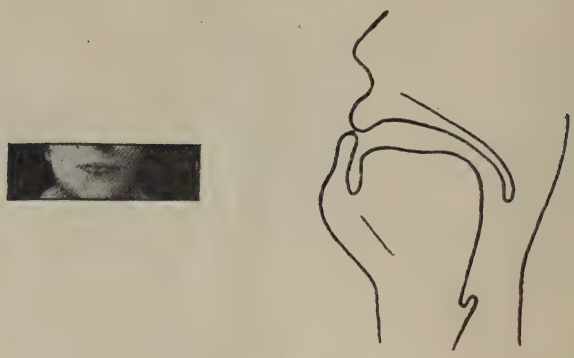


Figure 86. — *M.*

F.

The upper lip is set against the upper dental arcade, in such a way that the incisive teeth, placed behind it, are visible. The lowered jaw is carried somewhat backwards and the upper border of the lower lip brushes the upper incisive teeth. The soft palate is raised against the pharyngeal wall. The base of the tongue, drawn towards the roof, comes into contact with it upon two points of its lateral edges. When the emission of this consonant takes place, the chin is carried backwards, and the upper lip is placed below the upper incisive teeth. There are no laryngeal vibrations (Fig. 87).

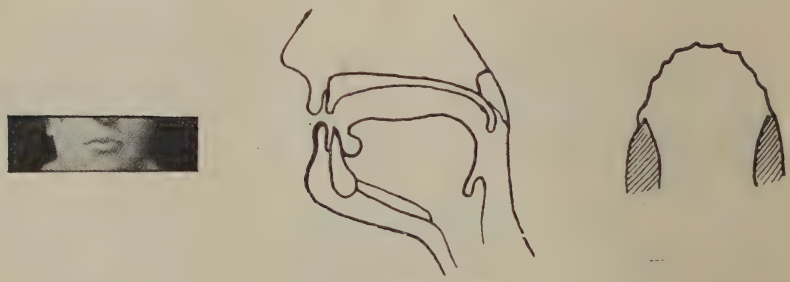


Figure 87. — *F.*

V.

The mouth presents the same aspect as for *F*, but, here, a laryngeal rustling noise is produced. The tip of the tongue is put against the lower teeth.

S.

Both the lower and the upper dental arcades are approximated, without however touching each other, leaving the teeth visible. The sides of the tongue rest against the alveolar crown of the upper

molar teeth until the canine teeth, and the lip is placed behind the lower incisive teeth, so as to build a narrow channel in which the air current breaks itself against the edge of the teeth, thereby producing a whistle : *S*, hence the appellation of sibilant given to this consonant.

To pronounce *S* correctly, one must not put the lips too much forwards, but one must bring the tongue further against the lower incisive teeth, without letting it touch the upper ones, and without pressing the teeth together (Fig. 88).

Figure 88. — *S*.

Z.

The position is the same as for *S*, but here the laryngeal noise occurs (Fig. 89).

Figure 89. — *Z*

CH.

The lips, funnel-shaped, leave the teeth visible; these are a little more separated than for *S*. The play of the organs is disposed like for *S*. The tip of the tongue is lowered, its back is brought close to the base of the soft palate. The whistling is less shrill than for *S*. The larynx does not vibrate (Fig. 90).

Figure 90. — *CH*.

J.

As for *CH*, with a laryngeal rustling noise. The palatal contact is lighter than for *CH* (Fig. 91).

Figure 91. — *J*.

T.

The tip of the tongue, being first set against the posterior face of the upper teeth, detaches itself suddlenly therefrom and goes behind the lower teeth. The sides of the tongue rest entirely against the upper incisive teeth, thus preventing the breath from coming out; then they fall down abruptly and place themselves behind the lower incisive teeth, producing violent explosion.

According to the vowel which accompanies *T*, the tip of the tongue is drawn more or less backwards. The soft palate is raised to prevent the air from penetrating inside the nasal chambers (Fig. 92).

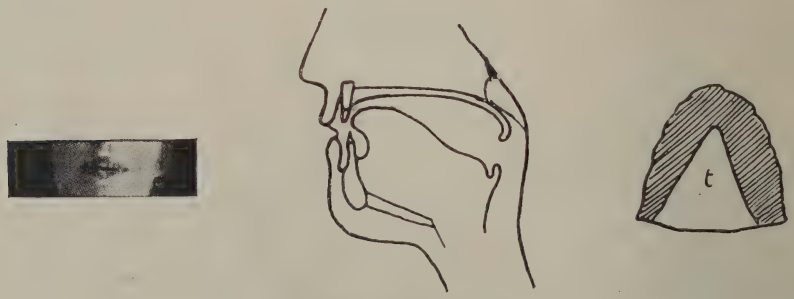


Figure 92. — *T*.

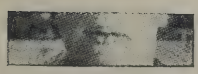
D.

The organs are placed in the same position as for *T*; but here laryngeal vibrations are produced, and there is a lowering of the upper-hyoidal region (Fig. 93).

Figure 93. — *D.*

N.

The edges of the tongue are laid against the alveolar borders; but the soft palate is lowered so as to give passage to the current which determines the vibration of the wings of the nose. There is no palatal contact against the incisive teeth like for *D* and *U*, but against their sockets (Fig. 94).



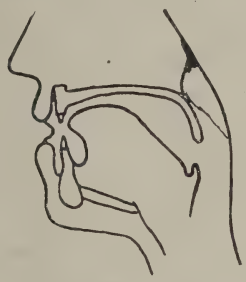


Figure 94. — *N.*

L.

The tip of the tongue is placed behind the upper incisive teeth; its median portion, which is raised, touches the sockets of the upper molar teeth; the breath passes between them and the sides of the tongue which vibrates slightly, so do the cheeks. The soft palate is raised (Fig. 95).

Figure 95. — *L.*

R.

The side of the tongue touches the palate lightly, the tip being placed behind the upper sockets. The air passes between the anterior part of the palatal roof and the tip of the tongue which vibrates rapidly.

In the guttural *R* (Parisian *R*), it is the extremity of the uvula which is set into vibration (Fig. 96).

Figure 96. — *R.*

K.

The tongue is carried backwards; its base is in contact with the soft palate which is pressed between the tongue and the wall of the pharynx. In detaching itself sharply, the tongue produces an explosion (Fig. 97).

Figure 97. — *K.*

G.

The base of the tongue is strongly laid against a wider palate surface than for *K*, and laryngeal vibrations are produced.

I do not intend to go further in this matter, and refer to articulation treatises the readers who are desirous of getting more ample information.

CHAPTER VII.

THE WORKING OF THE VOICE.

I will pass successively in review the way of attacking the sound, and of conducting it inside the cavities intended for the emission of the voice, so that it should come out under the most favourable conditions; this will lead me to explain what is the meaning of the improper word : *prop,* so frequently used by artists; then we shall see what is inferred by the terms *chest register* and *head register,* which have created an artificial division in the homogeneity of the voice. The registers will be the subject of a special chapter.

Attack of the tone. — What is the way of carrying out the process of engendering the tone, or to be faithful to the usual expression, how ought it to be attacked?

Though the question of the attack of the tone has raised sharp and numerous controversies, one must nevertheless recognize that the majority of singers reject the mechanism of the *shock of the glottis,* including *Garcia* and *Faure,* who however describe it in their works. Indeed, *Ch. Battaille,* a pupil of *Garcia,* declares that « his dear master indicated it but never used it ». *Faure* who advised attacking the sound by means of the pinching of the glottis, did not use it neither, according to all those who have heard him sing (I myself am of the number).

Besides, the authors do not agree as to the exact meaning of the expression : shock of the glottis; some designate by these words the emission without any effort or normal emission, whilst others give this name to the attack which is produced by means of a sharp and vigourous shock of the abrupt approximation of the cords and of the pinching of the glottis.

This expression strikes me as being badly chosen to designate the soft and open attack which is made without any violent contraction or effort, the word « shock » bringing immediately to the mind the idea of an effort. If we lift a pencil or any object from a table, one stretches out the arm without rashness and without mak-

ing an inordinate effort as if we had to deal with a weight of thirty kilos. It is just the same for the voice. The term « shock of the glottis » induces the pupil who does not know the disposition and the working of the organs of the voice, to contract abruptly the muscles of the larynx, so as to prevent the air from passing between the vocal cords, at the same time as he endeavours to contract the midriff and the thoracic muscles violently, so as to drive out the air from the lung and to accumulate it under the cords. By doing so, he is forced to make use of the *abrupt attack*. This expression seems to me the most correct one for describing this mode of attack, and if it were employed would prevent all possible confusion.

Abrupt attack. — When one utters a cry, or when one hails somebody from far, one imparts to the muscles an effort which translates itself by an abrupt approximation of the vocal cords. This is the *abrupt attack;* it is an exaggerated shock of the glottis.

In the abrupt attack, the glottis, shut by the approximation of the vocal cords, must resist for a short time to the pressure of the expired air which comes out with a kind of explosion; in certain cases even, when this effort is exaggerated (*forced shock of the glottis*) the ventricular bands come together and join. This effort requires a rather violent contraction of the midriff and of the muscles of the thorax and of the neck, which often causes the sounds to be sung above the tone and gives the voice a guttural timbre. But soon appears fatigue with muscular relaxation, which leads the artist to increase the pressure of the expired air so as to give the right pitch, hence a greater fatigue still which renders the singing painful and even impossible.

With the laryngoscope one is able to observe the close approximation of the vocal cords, and sometimes also the participation taken by the ventricular bands in this movement of adduction. *Seeman* has experimentally domonstrated that the shock of the glottis takes place 1/60th of a second before the beginning of the vibration. A graph taken simultaneously on the level of the thorax and the abdomen, by means of a registering apparatus, shows that the respiratory curve undergoes a slight projection immediately after the inspiration, and follows a rather marked ascending line before being continued by a more horizontal line (Fig. 98, *P*). If the thoracic and abdominal graphs are taken, it will be noticed that the latter is much more developed in men, whilst the thorax graph is more accentuated in women.

The graph of the laryngeal vibrations, taken with the exploring cap, rises suddenly in the shape of a hook with a rather acute angle, which is generally preceded by another little hook (Fig. 98, *L*).

The phonographic outline (Fig. 99) shows that the period has been influenced by the effort of expiration; its intensity is irregular.

Weak attack, or attack on the breath. — Another defective mode of attack is similar to what happens for the process of the emission of the continuous or sustained consonants. This attack is effected without any stopping of the breath by the vocal cords, which are no longer sufficiently joined together, but only approximated : this is the attack on *sustained respiration.* The singers who use this emission are said to be *singing on the breath;* it would be better to call this form of attack: *weak attack,* by opposition to the previous one.

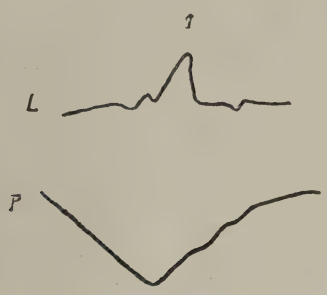


Figure 98.
Graphs of the respiration, *P*, and of the laryngeal vibration, *L*, in the abrupt attack.

A small quantity of air goes out before the position required for the production of the tone has been taken by the vocal apparatus. This air, which is not utilized, escapes in producing a somewhat blowing characteristic noise. *Garcia* had given this kind of attack the name of *shock of the chest.* The singers who attack the sound in that way are sometimes said to be singing as in a lamp-glass.

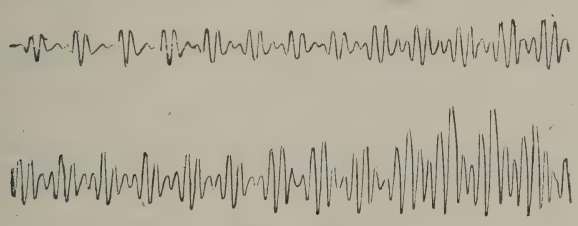


Figure 99.
Phonographic outline by abrupt attack. The line has a duration of 1/20th of a second.

To sing on the relaxation or *to yawn the tones* are expressions used by professional people, to designate a different form of the foregoing emission. The muscles of the pharynx, of the soft palate,

of the tongue, of the cheeks and of the lips have no longer the tension required by these different organs for producing the sound. One sings slackly, with the result that the note is attacked under the tone: in theatrical style, this attack is often called : *underneath attack*.

With the laryngoscope, one can see that the vocal cords stretch apart before the formation of the sound, and let a small amount of air come out, then they approximate again.

The graph shows that the respiratory curve rises rather rapidly, and then stretches out immediately after the attack has been made (Fig. 100, *L*).

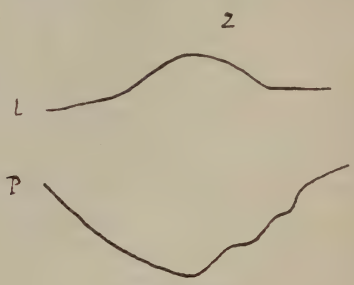


Figure 100.
Graphs of the respiration, *P*, and of the laryngeal vibrations, *L*, in the weak attack or attack on the breath.

On the phonographic outline (Fig. 101) the real form of the period appears only after a certain number of tenths of a second.

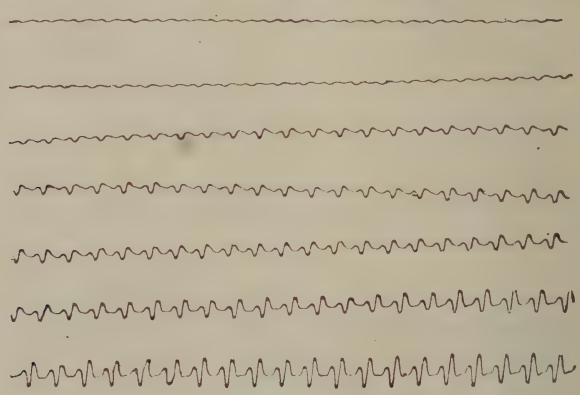


Figure 101.
Phonographic outline by weak attack, on the breath.
Each line of the graph has a duration of 1/20 of a second.

Normal or physiological attack. — To understand clearly the way to proceed so as to attack the tone normally, one must go back

to what we have previously said concerning the production of the explosive and of the continuous or sustained consonants. The former, like *b, t, c, d,* are due to an abrupt modification in the position of certain parts of the mouth, which lets the air escape sharply, whilst the sustained consonants *f, v, z, s* . . ., are engendered without the stopping of the breath which accompanies their articulation.

It is the same in the case of the tone formed in the larynx. The laryngeal sphincter, in contracting, brings nearer together, without any effort, the vocal cords which approximate by their borders, so as to intercept the expired air, in the same way as the lips come softly together for the utterance of *b*. To produce this consonant one does not try to obtain a sharp pressure of the expired air by asking a violent effort from the midriff, so that the air should be rapidly driven out of the mouth; but by the approximation of the

Figure 102.
Graphs of the respiration, *P*, and of the laryngeal vibrations, *L*, in the normal attack.

lips, one cuts momentarily the current of expired air which, at once, pursues its forward course by means of the sudden stretching apart of the lips, thereby producing the explosive consonant *b*.

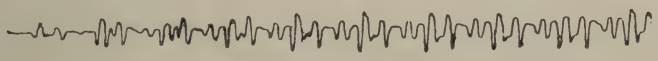


Figure 103.
Phonographic outline of the normal or physiological attack of the tone.

Thus the vocal cords, in approximating, cut the air column at the same time as the organs (ventricles, pharynx, mouth), which go to produce the emission of the desired note, are set into vocal function.

To learn how to attack the tone correctly, the pupil must practise some preliminary exercises on « *batacada* » for instance, so as to be able to understand clearly how the production of the explosive consonants take place; in that manner he will succeed in obtaining with his larynx a similar explosion. This is what *Faure* meant when he gave the counsel « of attacking the tone by pinching the glottis » (in other words by joining the cords together), so as to

give the vowels the spontaneity of the consonants *b, t, d, p,* creating, so to speak, factitious explosive consonants.

With the laryngoscope one observes that the sound comes out at the moment of the approximation of the cords.

On the pneumographic graph (Fig. 102) the line of expiration rises normally as soon as the voice is formed, that is when the air is expelled; on the graph of the laryngeal vibrations there appears a slight hook with a rounded point, at the beginning of the expiration.

The graph of the phonograph proves that the periods become normal nearly from the moment the sound is produced (Fig. 103).

Production of tone. — To be able to understand clearly how the emission of the tone is produced in the vocal organ, one must first of all consider in what way this production takes place in certain musical instruments or apparatus.

When one blows into a tube, it is observed that the maximum speed is to be found on the axis of the tube, and the minimum speed along its sides. This decrease of speed is attributed to friction.

On the contrary, if the gaseous current runs into a bell shaped tube, a funnel for instance, the speed is highest along the sides, whilst it is very low, and even negative, along the axis. This effect can be controlled by means of a candle which cannot be extinguished when one blows upon it through the narrow extremity of the funnel, if the breath is in the axis of the flame. The result is different if the flame is on the prolongation of the wide edges of the cone, as it is there that the wind comes out with its maximum of speed.

Furthermore if this experiment with a candle is made with great care, one can observe not only the presence of *going out* or *centrifugal currents* near the sides, but also of *going in* or *centripetal currents* at the centre.

The latter currents which go up along the axis of the funnel, are rendered evident by means of the well known experiment which is made with a cork ball placed on a small wire support surmounted by a funnel. If one blows through the tube of the funnel, the ball rises and stays in that position during all the time one keeps blowing.

This experience is successful if the angle of the funnel at the top is equal or inferior to 45°. If the angle reaches 180°, the ball is projected by the gaseous jet which has become central again.

To make the localization of the phonic centre clearly understood, in other words to locate the spot from where the sound starts, viz. the origin of the tone, and render the vibrations which evolve therefrom visible so to say, let us have recourse to a well known experiment : let us throw a stone into water. A series of circles

form themselves around the place where the stone has fallen. These spheric waves move further and further away from the centre. If they encounter some obstacle in their course, the circle is stopped at the point touched by the obstacle; the original convexity is destroyed and becomes concave on this spot, whilst the rest of the circumference keeps the original convexity.

The observation of these concentric circles is easy when they are formed on a liquid surface, but not when they are produced in the air around the sonorous point. Here, sonorous waves are formed in the air, all around the central point which then move further and further away. Our ear enables us to locate this sound, and to say that it comes from the centre of the sonorous waves by which our ear is struck.

Now, let us imagine that sonorous body is in vibration at the top, *C*, of a funnel (Fig. 104).

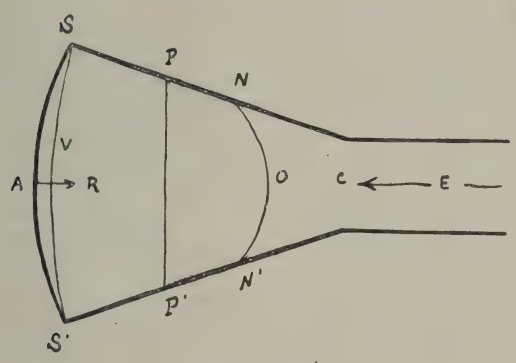


Figure 104.
Course of the sonorous waves in a funnel.

One of these waves is represented just at the mouth of the funnel, viz. *SAS'*.

If the wind comes from *EC*, it will modify the original curve, *SAS*, of the outlet waves of the funnel.

The air currents which are centrifugal near the sides, that is the waves projected outside the funnel, will be centripetal along the axis, *AR*, like the waves mentioned in the experience of the cork ball and the funnel. The speed of the sound will increase towards the circumference and decrease at the centre, so that, if the sound is not too strong, the spheric wave, *SAS'*, will be transformed into a convex wave, *SV'S'*, owing to the air coming in again along the axis.

If the wind is sufficiently strong, the spheric wave, *SAS'*, will even be changed into a plane wave, *PP'*, as the force of expulsion of the air along the sides will then become equal to the re-entering

force, *AR*, of the air inside the funnel. The re-entering air currents will neutralize the currents which go out.

Finally, if the funnel is only slightly open and the wind is very strong near the summit, *C*, the sonorous wave will become concave: *NON'*, owing to the force of the violent current which comes in, according to the direction of the arrow, *AR*, that is along the axis of the wide portion of the funnel.

One knows that in physics, there are real and virtual focus which occupy variable positions, behind or in front of the generative cavities of the sound. The ear locates the presence of the sonorous body at the centre of the wave curvatures which go to impress it.

The position of the sonorous centre is determined by means of the shape taken by the sonorous waves, at the moment when they escape out of these cavities spread in the ambient air.

Therefore this shape depends of the whirling winds which are formed inside these cavities, and which create very unequal speeds of propagation of the sonorous elements in different directions.

These sonorous waves may be either convex or concave, in all cases the focus is situated at the centre of the curvature. If the going wave is convex, the centre of the curvature is assumed placed behind the curvature, inside the cavity, and it defines an inner focus which gives a *dull timbre*. On the contrary, if the sonorous wave is concave, its centre of curvature is situated in front of it, before the cavity, and defines an outer focus which renders a *clear timbre*.

Let us apply these data to bell instruments.

The various bells of the instruments have for effect to create virtual sonorous bodies differently placed, inside or outside the tubes of the instruments.

A short and narrow bell, limited to *NON'* (Fig. 104), gives at its outlet a concave curvature, *NN'*, the centre of which is in front of the bell. There will therefore be in front of the bell an isolated and free sonorous body, which will produce a clear sound, like in the horn.

The same air current, in a somewhat longer bell produces a plane wave, *PP'*, of which the essential characteristic is to be propagated in one direction only, along the axis *CORA*. This bell is the ideal one for a speaking-trumpet.

A still longer bell gives a wave, *SVS'*, very slightly convex, of which the centre is placed inside the tube of the instrument, hence the shut and snuffing timbre of the hautboy, the bassoon and the clarinet.

I will now apply to the study of the voice, these data which have been so well exposed by *Guillemin*.

The voice, engendered in the ventricles of *Morgagni* by the cyclones of *Lootens*, creates first underneath the lid, then in the pharynx, sonorous waves which vary with the shape of these parts.

According as these pharyngeal waves are more or less convex or concave the sonorous body, situated at their centre of curvature, is localized in different places : either at the top of the head if the wave is concave; either at the bottom of the throat if the wave is convex; or else it will go much further down, « *in the boots* », if the sonorous wave is very little convex and comes nearer the plane wave. This is easy to explain by reason of the position of the centre of the circumference which is very low, the radius being very long.

Let us follow the course of these sonorous waves. When they reach the buccal bifurcation, the waves are transformed again.

The mouth acts in the same way as a bell, and every change in the shape of this bell creates special sonorous waves, which have a characteristic curvature in coming out of the lips.

If one goes back to the virtual sonorous body, placed at the centre of the curvature of these waves, it will be discovered in different parts of the head, either above, or below, or even behind the nape of the neck; it is found above the palatal roof; one will be able to say that there is a reverberation of the sound on the roof.

This is the explanation of the terms used by the singing-masters to express the inner sensations they experience : if the mouth is widely open, as in the bell of the horn, the virtual sonorous body will be placed in the mouth itself, hence the expression : *to sing in the mask*. If the going out wave is plane, the *voice carries*, that means that it will be heard from far. But if the sonorous wave is convex, one will *sing in the throat* : the voice is wrongly placed.

If the mouth is not very open as for the pronunciation of *o* for instance, the sonorous waves can only have as centre the buccal orifice itself; the sound will seem to take birth from this orifice.

Clear and sombre emissions. — The voice is said to be *clear*, or the sound, *open*, when the emission is similar to the one of the vowels *é* and *i*; on the contrary, one says that the voice is *sombre* or that the sound is *shut*, when the emission resembles the one of the vowels *a* and *o*. To designate these voices, one uses also the expressions : clear emission or clear timbre, and sombre emission or sombre timbre.

In the clear timbre, the larynx occupies the high position; the lid is raised, the base of the tongue is projected forwards; the pharynx is enlarged in its antero-posterior diameter, but narrowed transversally; the labial commissures are stretched apart; the mouth is somewhat largely opened; the organs are disposed so as to utter *i* or *é* (Fig. 104). One often makes the mistake of exaggerating this

disposition by opening the mouth inordinately, and by raising the larynx with excess; the voice obtained thus has no brightness, no call, and goes under the appellation of *blank voice.*

On the contrary, in the sombre timbre the larynx is lowered like the tongue, the back of which draws back, thereby narrowing the pharyngeal cavity in its antero-posterior diameter; the lid is bent backwards and hidens the anterior part of the glottis; the soft palate occupies the lowest position; the orifice of the mouth is rounded, the lips and the jaws, approximated as in the utterance of *o*. The buccal cavity is increased and the pharyngeal cavity, diminished, contrariwise to what takes place in the clear emission.

The lowering of the larynx in the sombre voice is the mean of hiding more surely the phonic centre, whatever the vowel pronounced and whatever the shape of the buccal cavity.

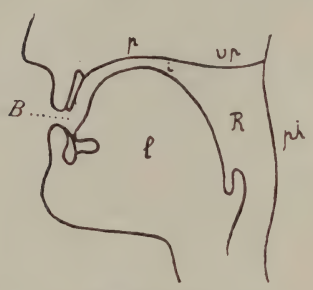


Figure 105.
Position of the organs in the clear voice. The bucco-pharyngeal cavity is divided into two parts : the anterior being smaller than the posterior.

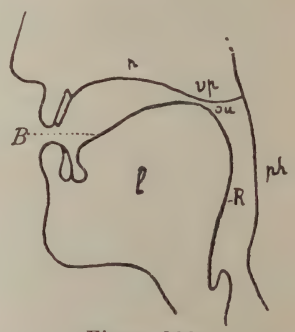


Figure 106.
Position of the organs in the sombre voice.

If one compares the two figures 105 and 106, one sees that the pharyngeal, *R*, and buccal, *B*, cavities possess inversily proportional dimensions according to the timbre. On figure 106, the front part, *B*, fills nearly the whole of the mouth.

As the larynx is lowered in the deep notes, and as on the other hand, the tongue draws back for the sounds *o* and *a*, thus facilitating the lowering of the larynx, it is easy to understand that the basses are more easily inclined to use the sombre voice, and that their best tones are produced on the vowels *a* and *ou* in the deep notes.

In the sombre voice, the tones have less brilliancy, less strength and when it is overdone the sounds are smothered and become muffled and harsh.

The tones which go from Mi^3 to Si^3, when uttered from the chest, smartly in the sombre timbre, acquire, both in men and

women, a dramatic character (*Manuel Garcia*). Let us remark however that it is not always advisable for women to follow this counsel, as they run the risk of spoiling their voice by making a too frequent use of the chest voice in the high notes, like *Si*^{3}.

The sombre timbre is habitually used by the people of the south when they sing; this is apparently due to the predominance of the sounds *a*, *u*, *ou*. in the meridional languages.

When the chin is kept lowered in singing the larynx is prevented from rising, hence an excessive use of the sombre voice.

Duprez introduced in France this mode of emission, unknown in that country till there, but in great favour in Italy. He had learned it from the tenor *Donzelli*, who was one of the first to use and abuse the vocal strength and the chest voice. Many were the singers who, in endeavouring in their turn to imitate *Duprez*, lost their voice. *Nourrit* was one of the victims.

It is interesting to know the researches made by Dr. *Martel* on clear and sombre timbres. The duration of emission of a note sung in clear voice is 35 seconds, in sombre voice, this duration is 20 seconds; this is a proof of the fatigue felt by the singers who use the latter timbre.

Faure has made the remark that the sombre voice is due to an artificial swelling with resonance, which renders the tones dull and cottony, and that its sonority seems satisfactory only to the people who produce it. In green-room talk, one is accustomed to say of such voices that « they do not go over the foot-light ».

The same artist adds, not without reason, that the voice is open or shut according as it has been delivered on an open or on a shut vowel, and that it is possible to sing continually either in open or shut voice on the condition only of altering the ringing tones peculiar to the shut vowels *é*, *i*, *o*, *u*. The case could be the same if one tried to sing in shut voice on the open vowels *a* and *é*. Unfortunately certain composers, being unaware of these elementary facts, write, under these notes, vowels which are unsuited to them; the result is that singers alter sometimes the words they have to sing, so as to attain a pure emission of the voice.

One sees with what difficulties the artists, who use this timbre, have to wrestle to produce the shrill notes, as they must keep their larynx in the low position to produce the sombre voice, and as they must, at the same time, let the larynx rise in the throat, so as to be able to deliver the shrill notes!

Props. — We have seen previously that each vowel is descried by the position occupied by the generative orifice along the palato-lingual channel, variable in size according to the more or less close approximation of the tongue and the palate. Thus, *i* requires a posi-

tion of the tongue such that its tip comes to rest on the anterior part of the palate. The sound which produces this vowel runs through a narrow channel, according to the longitudinal axis of the mouth, before coming out behind the upper incisive teeth and the upper lip.

For *é*, the channel widens; the generative orifice is carried back towards the middle portion of the palatal roof.

For *ou*, the generative orifice, requiring at the same time a backward displacing of the tongue and an enlargement of the linguo-palatal channel, is practically on the level of the joining point of the soft palate with the roof.

To these various points the singers have given the name of *props*. As they ignore the mechanism of the organ itself, they can only observe that they direct their breath forwards at a certain spot of the palate : they have the impression of pressing upon this spot. The *palatal prop* is so called, because the breath is sent to strike on this region.

The prop is the place where the air column, thrown by the bronchi and the wind-pipe, after having gone through the wide distributer, encounters its *resistance*, to which it *adheres*, and where it finds its point of support (*Isnardon*). If one wishes to express more scientifically this impression felt by the artist, one should say that : the laryngeal tone encounters, on a certain spot of its course through the mouth, a resistance which is due to the narrowing of the palato-lingual channel, at the generative orifice of the sound.

Summarily, to say that one has a good prop, means that the tongue forms with the palate a sphincter, at the spot necessary for the production of the vowel, at the same time as the vocal organs take the position and the shape required, so as to produce the voice and the articulation (see p. 154).

CHAPTER VIII.

THE VOICE REGISTERS.

The authors, taking as basis the disposition of the vocal cords in the series of the tones, have described up to five registers; but most of them are content to divide the voice into two registers.

The production of the deep tones of the bass, and the production of the shrill tones of the tenor do not take place by means of the same mechanism. In the deep tones, the voice is full and is accompanied by a resonance of the thoracic walls, hence the name of *chest register;* this register is more correctly called *deep register.* On the contrary, in the high tones the voice is shriller, more flute like, and the resonance is specially produced in the upper-glottic parts of the sonorous tube, hence this register has been named *head-register,* or falsetto, and also shrill register.

Let us add that certain tones can be delivered in both registers, therefore a third register has been created : the *mixed register,* or *voce miste,* or *medium.* These are the ideas generally received in the singing world.

I object to the expressions : chest voice and head voice; firstly, because there are not several voices, but one voice only, produced in the same way, though it undergoes certain modifications in accordance with the manner of delivering the tones, and setting into play the cavities of resonance; and secondly, because the head notes have not the exclusive faculty of sounding in the head, when even they sound there. The vibrations are very perceptible at the top of the head for the shut vowels *ou, u, î,* less intense for the half shut vowels *au, é, eu,* and weak for the open ones *a, o, è, e, an, on, in* and *un.* The contrary occurs in the chest resonance; the thoracic vibrations increase proportionally to the opening of the generative orifice of the vowel, that is of the linguo-palatal sphincter. It is easy to control these differences in the vibrations, by placing one hand on the chest and the other on the top of the head. When one utters *i,* in deep voice, one observes that the maximum of resonance is at the vertex, whilst for *o,* the thorax is more strongly affected.

The expert singers manage to pass smoothly and without transition from one register to the other; but such is not the case with many women who, having fine deep notes, abuse them, and end by giving the sensation that they possess two completely different voices, as may be frequently observed in our French lyric theatres.

One ought not to feel the passage in the emission of the voice.

The two registers are superposed in the extreme parts of their compass, but they pass each other mutually, the lower register extending more towards the deep tones and the upper register more towards the shrill tones.

In men, the high register scarcely passes the deep register more than an interval varying from a third to a fourth; sometimes however it can extend to a fifth, or even a sixth, but it is not without danger for the voice.

In women, on the contrary, the deep voice is carried to about a fourth only beneath the shrill register. It is not safe to *go up* too much *in chest*, according to the usual term, for the passage from deep to shrill register is not so easy as the passage from shrill to deep register. *Faure*, very sagely, advises women singers to use the resources of chest voice with the greatest caution only, he calls this register a double-bladded weapon, as dangerous as difficult to handle.

Battaille has, with a word, characterized this exaggerated manner of singing in chest voice by saying that « in contralti, the tones are sometimes not tones but *degueulando* [1] ».

To spare the singers who abuse this mode of singing an unavoidable accident, it is necessary to advise them to make the passage of the voice, in other terms, the change of register, between *Mi*^{3} and *Sol*^{3}. But tenors and contralti do not often keep to this rule. Then, what is the mechanism of this passage of the voice?

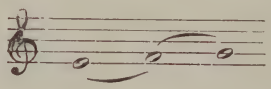


Figure 107. — Passage of the voice.

In the emission of a deep note the larynx stays in the neck, and the ventricles are set into play by a relatively weak air pressure. In proportion as the tone rises, the larynx rises also; the muscle thyro-arytenoideus contracts so as to lessen the capacity of the ventricles, the anatomical disposition of which helps the action of the muscle and reduces its volume more and more, compressing its walls, specially on the outer side, according to the dispositons

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1 Intranslatable expression which has been constructed with the very vulgar French word : *gueuler*, for *to bawl*.

of the thyro-arytenoideus; but at the moment of the change of register there occurs a very precise impression of relaxation inside the larynx, which is due to the setting into function of the crico-thyroideus; this muscle brings the cricoid close to the thyroidal, lengthens the vocal ligaments and narrows the entrance of the ventricles. The diminution of the opening of the cavity causes the tone to be uttered higher without the air current being strained.

One may easily verify this change in the action of the muscles by means of the following experiment which I have often repeated.

Marey's drum, and better still a laryngograph (Fig. 68), is placed on either side of the neck in the space included between the thyroid and the cricoid. By joining it to a registering drum (Fig. 11) a graph is obtained, which is the more rectilinear as the passage from deep to high register is less marked, and contrariwise the more broken as the passage is more accentuated, viz. according as the contraction of the crico-arytenoideus is progressive or abrupt.

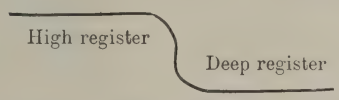

Figure 108.
Graph of the passage of the voice for a tenor. The difference between the two registers is extremely marked.

The constant action of this muscle narrows the capacity of the ventricle which, thanks to a strong pressure of the air current, provokes the production of shriller and shriller notes.

In conjunction with the occurrence of this phenomenon inside the ventricles, an increasing rising of the larynx takes place, in proportion as the pitch of the voice becomes higher, and also a more and more considerable narrowing of the pharyngeal walls, with a parallel rising of the soft palate. The tone is then reinforced in all the upper-glottic cavities : laryngeal cavity, sub-epiglottic cavity (*laryngeal aditus*), pharyngeal, buccal and nasal cavities.

Moeller has been able to verify this mechanism of the passage of the voice at the moment of coming into action of the crico-thyroideus, by means of X-rays.

CHAPTER IX.

THE COMPASS OF THE VOICE.

The whole of the tones which can be delivered constitutes the compass.

The tones uttered by the human voice include just above three octaves. They go from *Fa*[1] (174 s. vibr. or 87 doubl. vibr., or better still 87 periods) and even from *Ut*[1] (65 periods) to *Ut*[5] (1,044 periods) (Fig. 109). But the voice of each singer does not cover the range of the vocal scale.

Tessiture. — According to the individuals and to the sex, the voice corresponds to more or less high parts of the vocal scale. The tessiture is bound to the dimensions of the ventricles of the larynx and to the condition of their muscles.

Therefore, the tessiture is the portion of the vocal key-board where the singer feels most at his ease. The same expression applies to the few notes on which the composer chooses to build his musical phrase and to which he recurs in preference (*Faure*).

The men's voices are divided into bass, barytone and tenor voices; and the women's voices into contralto, mezzo-soprano and soprano voices, this division ranging from deep to high tones [1].

The bass voice goes from . . .	*Fa*[1]	(87	periods)	to *Mi*[3]	(326 p.)
The barytone voice goes from . .	*La*[1]	(108,75	periods)	to *Sol*[3]	(391,5 p.)
The tenor voice goes from . . .	*Ut*[2]	(130,5	periods)	to *Ut*[4]	(522 p.)
The contralto voice goes from . .	*Fa*[2]	(174	periods)	to *Fa*[4]	(696 p.)
The mezzo-soprano voice goes from	*La*[2]	(217,5	periods)	to *La*[4]	(870 p.)
The soprano voice goes from . .	*Ut*[3]	(261	periods)	to *Ut*[5]	(1044 p.)

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[1] In children the first soprano goes from *Si*[2] (244 periods) to *La*[4] (870 per.).
In children the second soprano goes from *Si*[2] (244 per.) to *Mi*[4] (672 per.).
In children the third soprano goes from *Sol*[2] (195 per.) to *Ré*[4] (587 per.).

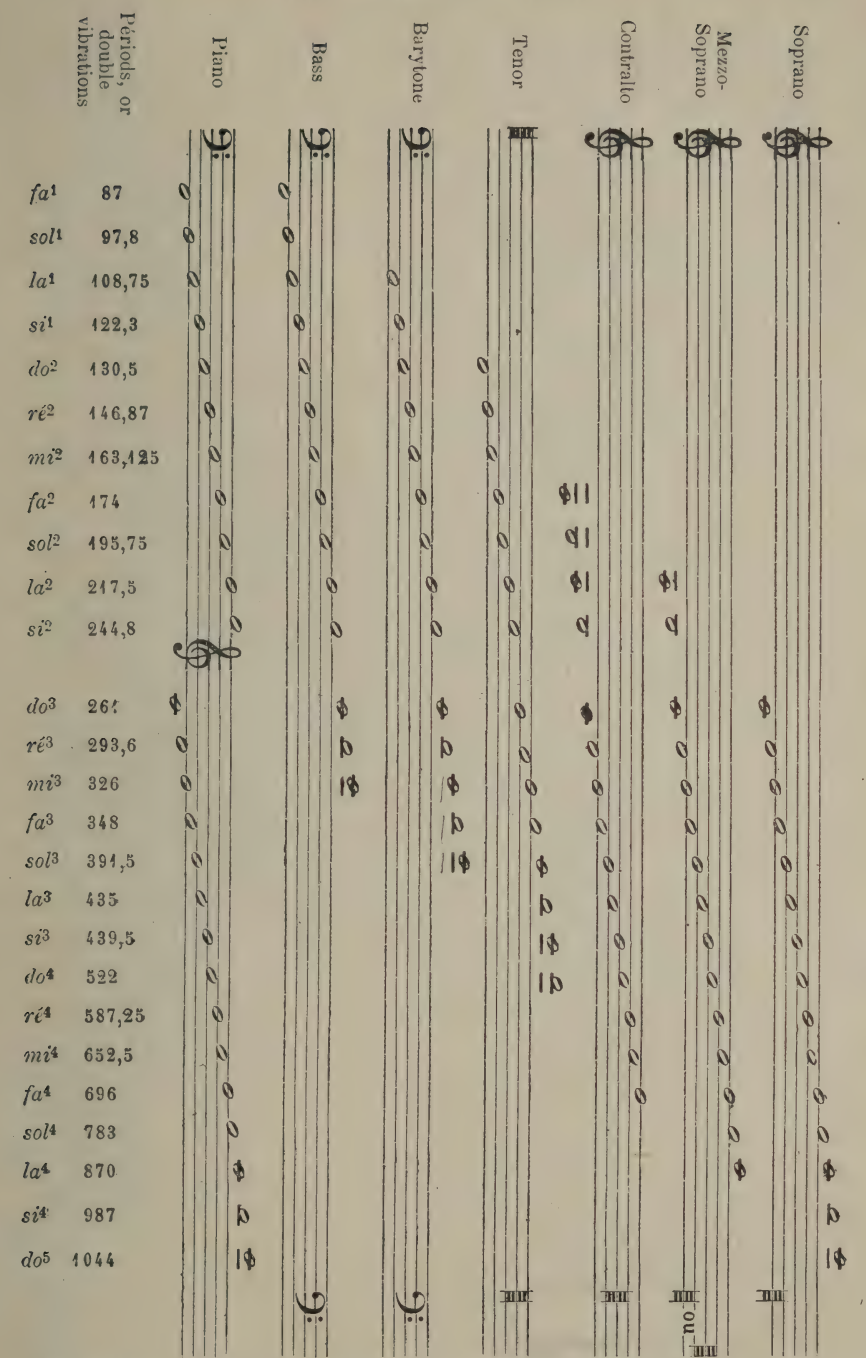

Figure 109. — Table of the different voices and their compass in relation with the notes of the piano. Barytone, Bass, Periods, or double vibrations.

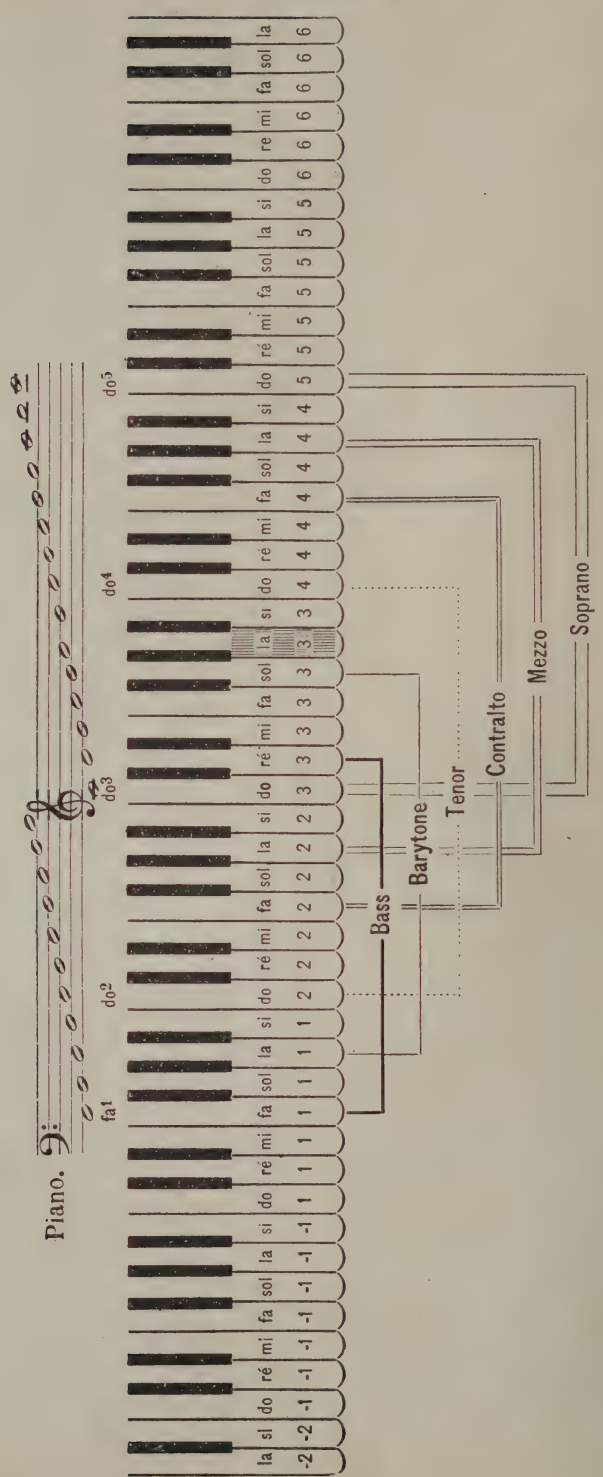

Figure 110.
Table of the tessitures and of their compass, in relation with the notes of the key-board.

In order that the tenor voice should occupy the right place on this table, recurrence has been made to the *Ut* clef.

The table represented on figure 110, shows the different tessitures in relation with the corresponding notes of the key-board.

The compass of each voice is the one generally admitted in the case of tutored voices. The men's voices follow in gradation of third to third; the bass starts at Fa^1, the barytone at La^1 and the tenor at Ut^2. The women's voices reproduce exactly from third to third the men's voices, but an octave higher; the contralto begins at Fa^2, the mezzo-soprano at La^2 and the soprano at Ut^3, as shown below.

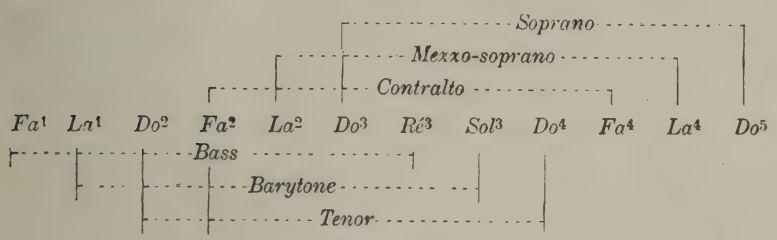

Figure 111.
Comparative table of the tessitures.

Masset has divided the voices in the following way :

Men : deep bass voice, corresponding to the double bass.

lyrical bass voice
tenor voice } corresponding to the violoncello.

Women : contralto voice, corresponding to the alto.

mezzo-soprano voice
soprano voice } corresponding to the violin.

The voices are also divided into :

Men's voices { Deep bass, Lyrical bass, Barytone, Strong tenor, Light tenor.

Women's voices { Contralto, Mezzo-soprano, Dramatic soprano, Shrill soprano.

Bass. — There are two kinds of basses : the deep, or thorough bass (bass-voice, « bass noble ») and the lyrical bass (« basse chantante »).

Deep bass. — This voice is the deepest of all the voices; it is voluminous and has a sounding timbre. It can reach down to

the *Ré*[1] even to *Ut*[1] (65 per.), but it passes with difficulty *Ut*[3] or *Ré*[3].

For this voice were written the parts of *Bertrand* (*Robert le Diable*) of *Marcel* (The *Huguenots*) and *Brogni* (The *Juive*).

These voices are to be found specially in Russia and in Germany; they have been mainly used by German composers.

The best known artists who have taken these parts are *Derivis, Depassio, Levasseur, Sarda, Obin, Belval, Boudouresque* and *Gresse*, the father.

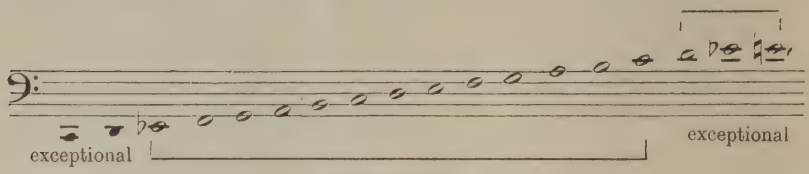

Figure 112.
Table of the voice compass of a deep bass.

Lyrical bass. — The lyrical bass, which is also called *deep barytone*, is the voice which is the most frequent in men. It is less hard, less voluminous, but also more supple than the former. It extends from *Sol*[1] to *Fa*[3].

In this voice, some head tones can be delivered, which coincide from *Ut*[2] to *Fa*[3] with the chest register; it can reach *Sol*[3] and *La*[3], but the effect of these tones, when produced in the thin register, being generally poor, it is advisable to deliver them in the thick register.

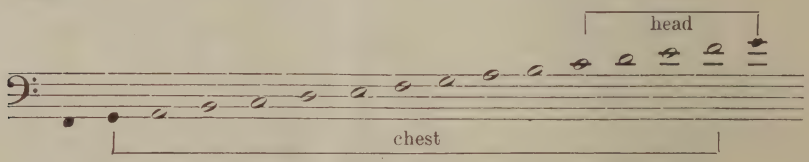

Figure 113.
Table of the voice compass of a lyrical bass.

The type of this variety of voice is to be found in the characters of *Max* (The *Chalet*). Some of the better known parts, which have been written for the lyrical bass are found in *William Tell*, The *Muette*, The *Siege of Corinth*, The *Favorite*, *Charles VI*, The *Queen of Cyprus*, *Mephisto*, *Faust*, *Capulet* and *Saint Bris*.

If, in the stock-plays of the modern Grand Opera, the lyrical bass has been replaced by the high barytone, it has, on the other hand, redeemed some importance out of the fact of the neglect in which the deep bass has been left by composers.

Let us name amongst its representatives : *Battaille, Troy, Ed. de Reszké, Plançon, Delmas, Taskin, Belhomme* and *Isnardon.*

In *Verdi*'s stock-plays, *Faure* takes the parts of a lyrical bass, and of a barytone in *Rossini*'s operas.

Barytone. — This voice extends from *La*[1] to *Fa*[3] in chest register and can ascend in head voice till *La*[3].

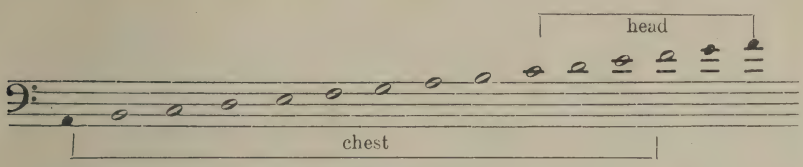

Figure 114.
Table of the voice compass of a barytone.

Verdi, A. Thomas, Reyer and *Massenet* have largely contributed to set off this voice. Among the parts written for the barytone are those of *Nelusko*, of *Macbeth*, of the *Count of Luna*, in the *Trovatore*, of *Rigoletto*, of *Hamlet*, of *Gunther*, of *Hérode*, of *Amonastro*, of *Carlos* in *Hernani.*

Let us recall some celebrated barytones : *Corsi, Graziani, Pandolfini, Merly, Beraldi, Ismaël, Devoyod, Baroilhet, Martin, Faure, Lassalle, Maurel, Melchissédec, Renaud, Noté, Fugère, Barré, Soulacroix, Bouvet, Baltestini* and *Tita Rufo.*

Some barytone voices are so much like tenor voices that they are not always easy to class if the tessiture only is taken into consideration. Actually, there are some tenors who, like real barytones, can hardly reach *Ut*[4] and even *Si*[3]. Their vocal cords are of a barytone, and their resonators of a tenor. This special type of voice goes under the name of *Martin barytone*, and its particular quality is agility.

Tenor. — The tenors are classed into two categories : the strong and the light tenors.

Strong tenor. — This voice is quite unusual; it is the ancient tenor *serio*, the tenor *di forza* of the Italians, personified by *Nozzari, Crivelli, Donzetti, Reina, Silva*, whose voice compass ranged from *Mi*[3] to *Ré*[5].

The strong tenor must possess a considerable voice volume. He sometimes abuses the chest notes, going thus from *Ut*[2] up to *Si*[3] and even to *Ut*[4], like *Tamagno*, and even reaching *Ut* ♮[4] like *Tamberlick.*

The tones common to both chest and head registers go from *Mi*^{3} to *Si* ♭^{3}.

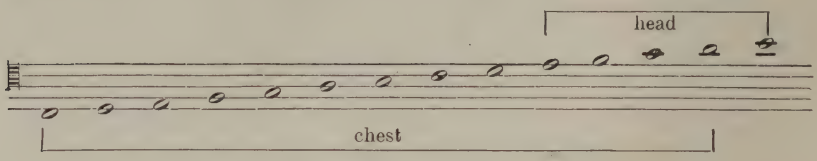

Figure 115.
Table of the voice compass of a tenor.

The strong tenor can sing *Robert, Arnold* (*William Tell*), *Eléazar* (the *Juive*), *Raoul* (the *Huguenots*), *John* (the *Prophet*), *Vasco de Gama* (the *Africaine*) and *Othello*.

Amongst the strong tenors let us name *Gueymart, Wachtel, Duprez, Tamberlick, Villaret, Tamagna, Salomon, Mierszinski, Duc, Escalaïs, Dupeyron.*

Beside these strong tenors can be placed the Opera tenors whose stock-plays include : *Faust,* the *Favorite,* the *Traviata, Rigoletto, Sigurd, Salammbô, Walther* (*Meistersänger*), the *Roi d'Ys, Esclarmonde.* The principal interpreters of these Operas have been *Rubini, Nourrit, Mario, Roger, Gayarré, Nicolini, Collin, Talazac, Ibos, Dereims, Sellier, J. de Reszké, Saleza, Alvarez, Van Dyck, Gibert, Affre, Bassi, Caruso, Jérome, Frantz, Muratore.*

Light tenors. — The light tenor possesses a greater softness and lightness of the voice than the strong tenor. To him devolve the parts of *Leopold* in *La Juive*, and of *Raimbault* in *Robert le Diable.*

Beside the light tenor let us place the comic-opera tenors who sing in the *Barber, Don Pasquale,* the *Dame Blanche,* the *Pré-aux-Clercs,* the *Mousquetaires de la Reine, Si j'étais Roi,* the *Caïd, Fra Diavolo, Lalla-Rouck, Mireille,* like *Garat, Ponchard, Capoul, Nicot, de Laquerrière, Mouliérat, Beyle, Clément.* To this list could be added the name of *Vaguet* who left the stage too soon unfortunately, owing to an unlucky operation against which I had advised him.

Contralto. — This voice is the deepest women's voice. It possesses power and sonority. It ranges from *Fa*^{2} to *La*^{4}. The chest register which is vigorous goes up to *Fa*^{3} and even to *Sol*^{3}; but as much as possible one must avoid giving his note « en poitrine », furthermore singing higher up in this register can bring ruin to the voice.

The stock-plays of the Contralto includes the parts of *Arsace* (*Semiramis*), *Orsini* (*Lucrèce Borgia*), *Orphée, Pygmalion* (*Galathée*), *Anna Boleyn* (*Henri VIII*), *Dalila, Astartée, Théodora, Vanina* (*l'Ancêtre*), *Açuzena* (*Trovatore*).

Their principal interpreters have been *Manghini, Pasta, Brambilla, Sessi,* the Younger, *Pisaroni, Alboni, Stolz, Wertheimer, P. Viardot*[1], *Marchesi, Richard, Bloch, Héglon.*

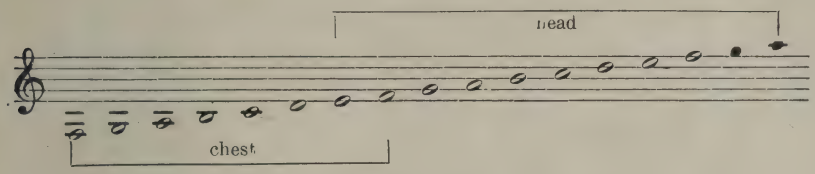

Figure 116.
Table of the voice compass of a contralto.

Mezzo-soprano. — Of all woman's voices, this is the most usual; it extends from *La*^{2} to *La*^{1}.

Its chest register does not possess the power of a contralto's; in return the mezzo-soprano is brilliant in the high notes of the head register.

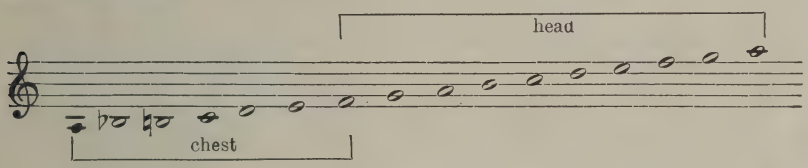

Figure 117.
Table of the voice compass of a mezzo-soprano.

The stock-plays of a mezzo includes : *Amnéris* (*Aïda*), *Leonore* (the *Favorite*), *Fidès* (the *Prophet*), *Carmen, Mignon, Didon* (the *Troyans*), *Hérodiade.* These parts have been held by *Grossi, Waldmann, Barlani, Galetti, Rosine Bloch, Galli-Marié, Richard, Engalli, Nina Pack, Charlotte Wyns, Calvé, Delna, Lapeyrette.*

Soprano. — The compass of the voice of a shrill soprano and of a dramatic soprano is about the same, with the difference that some notes can be given by the former with greater ease. The shrill soprano goes from *Do*^{3} to *Fa*^{5} exceptionally, whilst the dramatic soprano can only reach *Ut*^{5}.

The characters taken by a shrill soprano are: *Rosine* (the *Barber*), *Haydée, Orphelie* (*Hamlet*), *Mireille, Lakmé, Juliette, Inès* (l'*Africaine*), *Eudoxie* (the *Juive*), *Isabelle* (*Robert le Diable*), *Mathilde* (*William Tell*), *Bertha* (the *Prophet*), *Gilda* (*Rigoletto*), *Traviata, Manon, Mar-*

[1] Mme Viardot was endowed with a very extensive voice; she was able to sing *Orphée* and *Iphigénie.*

guerite (*Faust*), *Louise*, interpreted by *Cinti-Moreau, Ugalde, Duprez, Sontag, Albani, Jenny Lind, Marie Cabel, Gras, Nilson, A. Patti, Miolan-Carvalho, Melba, Heilbronn, Bilbaut-Vauchelet, Isaac, Van Zandt, Gall.*

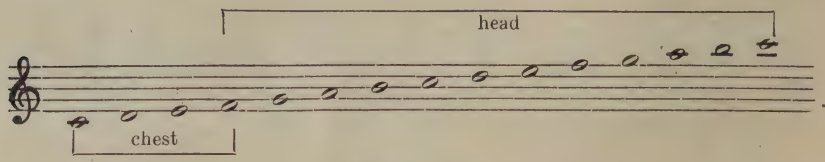

Figure 118.
Table of the voice compass of a soprano.

The dramatic soprano can sing the parts of *Lucrèce Borgia, Leonora* (*Trovatore*), *Alice* (*Robert le Diable*), *Valentine* (the *Huguenots*), *Rachel* (la *Juive*), *Chimène* (*Le Cid*), *Salomé* (*Herodiade*), *Brunehilde* (*Sigurd*), *Salammbô*. These characters have been held by *Meinvielle-Fodor, Lagrange, Catalini, Sontag* [1], *La Malibran, Cruvelli, Bosio, Penco, Dorus-Gras, Falcon, Gueymard, Marie Sasse, Krauss, Rose Caron, Dufranne, Litvinne, Bréval, Grandjean.*

Variations in the tessiture. — If we have fixed certain limits to the compass of every kind of voice, we do not intend to state that there are no exceptions to each rule, on the contrary.

For instance, certain tunes like « anges du paradis » in *Mireille*, « divins mensonges » in *Lackmé*, and « un ange, une femme inconnue » in the *Favorite*, where no note is higher than *La*^{3}, can only be sung by a real tenor voice.

On the other hand a light barytone, who possesses easy high notes, can succeed in singing the tune of *Sigurd* : « Hilda, vierge au pâle sourire », or of *Faust* : « demeure chaste et pure », or even of the *Huguenots* : « plus blanche que la blanche hermine » though the extreme notes of the tessiture of a tenor are contained in these tunes.

In the same way, a lyrical bass can grapple with the tune of *Max* in the *Chalet*, where there are several *Sol*^{3}; but is unable to sing : « jardins de l'Alcazar » of the *Favorite*, where there is only one *Fa*^{3}.

It has been seen formerly that an artist could easily possess a voice compass of two and a half octaves. It is well known that *Lablache, Geraldi* and *Levasseur*, were endowed with an extremely high register, though they had bass-voices.

In the cases of certain singers gifted with extraordinary qualities, the limits of the voice are again extended. For instance, the voice of the Danish chapel-master *Gaspard Forster*, who was a bass, covered

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[1] *Sontag* was at first a shrill soprano, and became later a dramatic soprano. We have seen previously that one of the causes of this alteration was the upraising of the border of the vocal cord.

three full octaves from *La*-$_1$ (54, 375 per.) to *La*^{3} (435 per.); *Catalani* and *Farinelli* possessed each three and a half octaves. The contralto voice of the youngest sister *Sessi* had a range of three and a half octaves too, and went from *Ut*^{2} (130, 5 per.) to *Fa*^{5} (1392 per.).

Certain basses have been able to deliver *Fa*^{1} and even deeper notes. Thus the brothers *Fischer*, who lived in the XVIth century at the court of Bavaria, and a singer called *Grasser*, named by *Prætorius*, could give *Fa*-$_2$ (21,75 per.) which is the deep octave of the note previously indicated as extreme note.

Other artists have also gone far beyond the upper limit which is generally assigned to soprano voices. For instance, the youngest sister *Sessi*, as aforesaid, could reach *Fa*^{5} (1392 per.), *Patti* and *Nilson* gave also this note in the tune of the « Queen of the Night » in the *Flûte enchantée; Sybil Sanderson* went up to *Sol*^{5}; and I am told that an american soprano, Miss *B. Yaw*, even reached *Mi*^{6} (2610 per.)!

According to *Mozart*, the voice of *Lucrezia Ajugari*, surnamed the *Bastardella*, who sang at Parma in 1770, had a range of three and a half octaves, extending from *Sol*^{2} (195,75 per.) up to *Ut*^{6} (2088 per.) which was believed to be the highest note delivered by a human larynx until Miss *Yaw* broke the record.

It is said too, that a lady named *Becker*, who sang at Petersburg in 1823, was also able to deliver this note *Ut*^{6}.

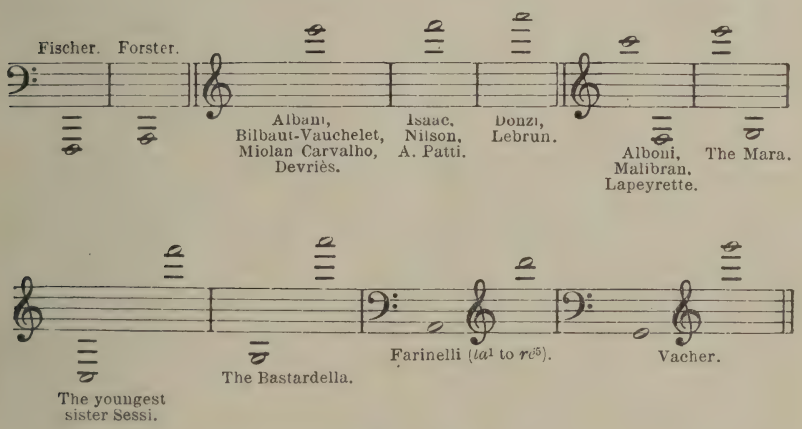

Figure 119.
Compass of the voice of a few artists.

The celebrated castrato, *Carlo Broschi*, surnamed *Farinelli*, can also be mentioned amongst the artists whose voice had an extraordinary compass; his voice covered three and a half octaves, from *La*^{1} (108,75 per.) to *Ré*^{5} (1174,5 per.). The most extensive voice to my

knowledge is the one of Dr. *Vacher*, one of my colleagues and a former student at the Conservatoires of Lyon and of Paris, who has written a thesis on *researches as to the mechanism of the voice*, in which he indicates *Sol*[1] (97,875 per.) and *Sol*[5] (1566 per.) as the extreme limits of the voice, thereby according to the latter a range of four octaves. Dr. *Vacher*'s chest voice goes from *Sol*[1] to *Ré*[4], and his head voice from *Ré*[4] up to *Sol*[5].

Another remarkable and recent case worthy of notice is the one of a woman tenor whose voice compass extends from *Ut*[2] to *Ut*[4] [1].

In her Memoirs, the Duchess of *Abrantès* had already mentioned a similar case : « The *Guaforini* possessed a bass-voice rather than a contralto. »

Classification of the voices according to the examination of the larynx. — On account of the fact that the longer the vocal cords the deeper the voice, and the shorter the cords, the higher the voice. Thus, the strong tenor and the soprano would be endowed with short large vocal cords, the light tenor and the shrill soprano with short lank cords, and the bass and the contralto with long, large cords.

It is evident that the difference between the kinds of voices is not without being partly due to the dimensions of the larynx and of the cords, which are in proportion to the development of the other parts of this organ, and specially of the ventricles, these, as I have already said, reaching in certain cases remarkable dimensions. It is habitually in the bass and the contralto, that one comes across vocal organs in their different parts presenting such large proportions On the contrary, in tenors and soprani the cords and specially the ventricles have lesser dimensions. In any case the vocal apparatus is larger in men than in women.

Let me repeat again that no exaggerated importance must be given to the vocal cords, as the cords of a soprano can sometimes be larger than those of a contralto.

In the question of the classification of the voices, the timbre must not be overlooked. *Battaille* has made the remark that the different voices, bass, barytone, tenor contralto, mezzo and soprano,

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1 This woman has been presented to the *Society of Laryngology of Vienna*, as a barytone, in February 1908. But owing to the ablation of the adenoids, her voice has won three or four notes in the upper register, so that it offers actually all the characteristics of a tenor voice.

O. Chiari, of Vienna, describes this woman's larynx as being remarkably large; the lid, the pyramids and the ary-epiglottic folds are thicker and more massive than in women; the vocal cords are wider, without being longer. Dr. *Cyril Habsford*, who has examined her some little time ago, is of the opinion that her tenor voice is due to a chronic laryngitis, which has been brought on by the fact of the singer having forced the chest notes.

differ not only through the pitch of the tones they can render, but also through their timbre, thanks to which it is impossible to mistake them for each other, even when they reach the regions of the musical scale common to all of them.

Faure, after *Battaille*, declares that the classing of the voices should be made according to the timbre rather than to the compass, as it is possible to possess a voice having a tenor's timbre, though it may not pass without effort *Sol*^{3} or *Fa*^{3} in chest register; therefore one ought to class the voices according to their timbre, and to the part of the vocal key-board where the singer is most at ease. We will see in due course that the registration of the voices gives infinitely more precise indications; in a doubtful case it is of all necessity to have recourse to it.

I could cite many instances proving that this classing of the voices has been tho source of numerous errors. Let me only say, at present, that *Elleviou* and *Mierszinski* have sung the basses before taking the parts of tenor, and that *Lherie* and *J. de Reszké* have sung the parts of barytone before becoming tenors.

How to determine the tessiture. — The voice which has not been rendered supple by practice is often rough, uneven, faltering and not extensive. Furthermore, it is never pitched in the natural limits of the tessiture; this is the reason why so many professors make mistakes, which have such disastrous consequences upon the career of the singer, when they range, for instance, the barytone amongst the tenors, or the contralto amongst the soprani, or inversely.

The intervention of a specialist would be most useful in certain cases for judging of the conditions of the vocal organs. In fact, the pupil ought to pass before « a board of examination », and enter the theatrical career only if his larynx, pharynx, nose and mouth are in a perfect normal condition. What is the use of letting a pupil study singing if his nasal chambers are obstructed, or if his breathing is defective? The first thing to do is to see that these organs should be put in the proper conditions so that they may be able to accomplish the work required from them. Otherwise the pupil will soon be under the obligation of breaking off his lessons, and somestimes even of stopping them altogether, owing to the disorders caused by the bad state of his vocal apparatus.

As I have already stated, the specialist can help the professor in determining the tessiture. It is often possible to judge of the kind of voice by the dimensions of the larynx, specially of the vocal cords which are in proportion, as aforesaid, to the size of the ventricles, and also by the shape and the capacity of the upper-glottic cavities.

The bass has habitually long, large and thick vocal cords, the larynx and the resonators are wide. The subject himself is generally tall and corpulent; the chest is ample, the neck, high with a marked projection of the Adam's-apple.

The strong tenor is frequently small in stature; the neck is thickest, the vocal cords are large and short, and less thick than those of the bass. The larynx is smaller, so are the cavities of resonance.

On the contrary, the light tenor's vocal cords are short, thin and narrow. The resonators are of smaller proportions.

The contralto's cords are long and large. The neck is long and the larynx, high.

The falcons have short but large cords.

Finally, the soprano has a small larynx with small and narrow cords. The cavities of resonance are equally small.

On the other hand, the professor is able to ascertain the tessiture by taking into account the timbre and the intonation of the voice, and also the facility with which the pupil utters the tones in a certain part of the vocal scale.

Besides, as will be seen further, the registration of the voice is an important factor in helping to determine the tessiture.

Battaille has made the judicious remark that though a barytone can go up as much as a tenor, the high tone which he can easily reach is not composed of the elements which are to be found in the same emission given for the same note by a tenor.

A light soprano can equally deliver a deep note just as a dramatic soprano, but her voice does not lose therewhile the shrill elements inherent to its timbre.

If one tries to suppress these elements and to replace them by deeper ones, in increasing the volume of the voice, viz. of the mould where the voice is elaborated, one strains the tessiture and provokes a vocal affection.

In accordance with the wise counsel of *Stephen de la Madelaine,* one must proceed first of all *by making the voice come out,* bringing out in a normal way all the tones of which it is composed; then one endeavours to get rid by study of all imperfections, learning how to pitch the voice, and how to hold a tone. It is here that the utility of the control by means of the phonographic graph, or of the projection of the vibrations appears clearly, as well for the sake of the pupil as for the safeguard of the professor.

The various parts of which the larynx is composed are not extensible, like an elastic band which can be drawn without peril, so as to increase the range of the voice; therefore it is better to proceed carefully at first and not to make the pupil sing along the

whole compass of the vocal scale, from the first notes of the bass or of the contralto up to the high notes of the tenor or of the soprano, as some singing-masters of our acquaintance are accustomed to do, under the pretext that this is the best way of choosing the kind of voice, according as the deep or the high tunes are delivered more easily.

It happens also that it is the parents who decide of the future voice of their children, and I know, as a fact, that mothers often bring their daughter to a singing-master, with their mind absolutely made in that their off-spring should become a soprano, notwithstanding the opinion of the professor aware that the girl has none of the qualities required for singing in this tessiture. In these cases generally, the result is soon evident. How many voices are lost in that manner!

CHAPTER X.

DISPLACINGS OF THE LARYNX.

The larynx is an organ which undergoes a series of change of place during the respiration, the emission of the voice and the articulation.

It rises in the deep inspiration and falls back in the forced expiration. It ascends in the production of the shrill notes, and descends in the emission of the deep notes. However, if the mobility of the larynx is very much marked in the lower part of the voice, it is less so in the high notes. *Hartess* has valued to 4 millimetres the rising of the larynx for each note. In the production of the shrill tones this organ reaches the height of the hyoidal bone.

In the utterance of the vowels, its position varies; it occupies the extreme lower limit for *a*, and rises progressively for *o*, *é*, *è* and *i*.

It is easy to observe these displacings by putting the finger on the neck, on the level of the Adam's-apple. If a deep note is uttered after a shrill one, one feels the latter slip under the finger.

Let us bear back to mind, that the tongue and the larynx are fixed to the hyoid bone on which muscles are also attached, some of which proceed towards the base of the skull and the others, towards the thorax; so that, according to the play of these muscles the larynx is carried either up or down, or even forward or backward.

As the emission of *i*, specially in high register, has for effect to carry the larynx up, advantage is taken of this disposition for fighting the inclination of certain pupils *to sing in the throat*, by tightening the neck, for the tip of the tongue, coming to rest against the front part of the palatal roof, obliges the larynx to rise.

It is thanks to a similar mechanism that the laryngologues can examine the vocal cords, which they are able to see by drawing the patient's tongue forward and making him utter *é* specially, as for the emission of this vowel the lid is raised.

Certain singing-masters, ignoring the play of the organs of phonation, advise their pupils to maintain their tongue constantly flattened against the floor of the mouth, without realizing that this is the way of bringing the tongue backwards and of lowering the larynx inside the neck.

One uses frequently the expression : *lowered larynx* to designate the position occupied by this organ in the emission of vowel *a*, and also *raised larynx* to indicate the position taken for *é* or *i*.

To leave the larynx free to move according to the circumstances, one must not try to keep it too much lowered by bending the head down for instance, or too much raised by looking up. If the voice must become supple and powerful, it is necessary that the movements should be executed without effort, without violent muscular contractions, without fixing into immobility an organ which would then be incapable of following its physiological function.

Natural philosophers, physicians, professors, like *Dodart, Malgaigne, Stephen de la Madelaine,* have judged that the total movement of the larynx had the function of adjusting the vocal tube relatively to the different sounds produced by the glottis, and that his ascensional gradation was in proportion to the pitch of the tones. *Segond,* who was both doctor and artist, has however formulated the remark that if this mobility of the larynx was very marked in the lower part of the voice, it was much less apparent in the high notes.

Other professors, like *Verdhurt, Delle Sedie,* etc., on the contrary advise that the larynx should be left to take the low position in the high notes, as, according to them, this helps the emission of the high tones, and as, inversely, the raising of the larynx makes the production of the deep notes easier. *Warot* warns « not to raise the head when one wishes to produce high sounds; on the contrary, one must be careful to leave the larynx in an absolute state of fixity; in this manner the voice will sound more easily in the larynx and in the nasal chambers ». This opinion of *Warot* is in contradiction with what I have just stated.

To remedy the thinning of the voice in the high tones, *Faure* gives the counsel not to lift the head, for the larynx advances then gradually till the fauces, and prevents thus the voice from sounding inside the pharynx and the cavities of the nose.

In Germany, a similar advice has been given by *Hauser,* whose method of singing rests upon the necessity of lowering the larynx to produce the sound. Dr. *Imhofer* and Dr. *Avellis* are also partisans of fixing the larynx in the low position, without raising the hyoid bone.

But *Barth* has proved, by means of radiographs, how grave was this error, and *Hermann,* whose studies on physiology and phonetics

are well known, has protested against this assertion, affirming without hesitation that the more the tone was shrill, the more the larynx had to rise. My personal observations have led me to the same conclusion.

It its evident that to obtain the low position of the larynx inside the neck, either to maintain it in its normal place or to lower it during the phonation, one must have recourse to the muscles which have for function to pull the larynx down; the larynx carries then in its movement the hyoid bone and the tongue which is attached thereto. One must « briddle up » by bringing the chin towards the neck, according to *Faure*'s counsel, if one wishes to produce shrill tones.

Segond, who did not agree, as has just been seen, with this way of displacing the larynx, had nevertheless observed that « in certain cases, one could lower the larynx to pass from one tone to a shriller one, as, for instance, when the larynx delivering without any violence *Do*^{3}, an effort had to be made suddenly so as to pass from *Fa*^{3} to *Sol*^{3}. This organ obeying to the lowering muscles, which tend to fix it vigorously, goes down below the point where it had been brought for the natural production of *Do*^{3} ». If one keeps the chin constantly down during the emission of the shrill notes, the contraction of the muscles of the neck hinders the play of the ventricle and, consequently, the movement of the thyro-arytenoideus which covers it.

Let us examine how this movement of the vocal organ is produced.

To obtain the displacing of the larynx towards the base of the neck, the muscles which are set into action must take a prop upon the thorax; this requires the fixity of the latter, and, consequently, the contraction of the midriff, and thereby impedes the respiratory function of the latter.

It is easy to realize what influence the displacings of the larynx have upon the respiratory mode. These relations extend still further. The breathing has indeed a certain action on the movements of the larynx.

Gutzmann, one of the phoneticians who has gone most into the vocal questions, in Germany, has noticed that the larynx keeps motionless when the breathing is calm; on the contrary, it performs movements of to-and-fro, if the respiration is deep and more energetic. Similarly, if various vowels are pronounced, the larynx maintains an indifferent position, it scarcely even follows passively the organs of articulation, except in the case of the consonants *l* and *r*, for which the vertical movements are more accentuated.

P. Hellat, too, has made the displacing of the larynx a matter of study : he has examined a great many subjects, artists as well

as amateurs, and has remarked that the people who sing naturally have another method than those who have practised singing. In the case of the singer endowed with a natural voice, the larynx is kept lowered during the production of the deep tones, whilst it is raised for the shrill notes. *Merkel*, and more recently *Hermann*, had already made a similar observation.

Though, according to *Hellat*, a certain number of artists have adopted this method, it is nevertheless true that the singers « who have followed singing courses ,or who have received the principles of the school » fix the larynx in its low position, bringing it therefore one or two centimetres below its normal position, no matter what tone is delivered. He adds however that for the light soprani, the larynx stays fixed up its upper position.

On his side, *E. Barth* has noticed that some artists when singing gave the larynx enough freedom, so that it should follow the pitch of the tones; the larynx was kept lowered for the deep notes, and rose for the shrill tones. *Barth* adds however that, thanks to the cultivation of the voice, many of them have acquired the faculty of moving their larynx contrariwise to the height of the tone.

After having made experimental researches to establish the relations existing between the movements of the larynx, tongue, maxillar and lips, *Gutzmann* and *Flatau* have come to the conclusion that there are two absolutely distinct types of movements. In the first type, one observes very marked movements of the larynx and of the jaw, in conjunction with scarcely perceptible movements of the buccal floor and of the lips as for the larynx, which during the phonation is situated above the normal position; it goes up and down with the notes of the scale. The second type of movement is to be found in most of the singers by profession, who execute small movements of the larynx independently from the progression of the tones; here the larynx keeps any position, whilst the tongue works, and whilst the maxillar moves slightly. By this contrivance the singers try to remedy to the operation of the displacing of the larynx, thus endeavouring to alter the generative orifice of the tone by means of a special mechanism, so as to obtain the best possible conditions for the concentration of the sonorous waves; this explains the faces which some artists make when they sing.

I rise against this way of proceeding, which consists of recurring to artificial means or « trucs », with the object of obtaining a result easily reached by those who sing with the natural voice, or voice which has not been altered by tuition.

As *Biaggi* says, the mobility and the fixation of the larynx depend from the schooling under which the artist has been formed. In certain institutions, the students take the habit of moving the larynx, whilst the pupils of other establishments are accustomed to keep it fixed.

Biaggi, like myself, is of the opinion that the method of fixation is very closely related with the respiratory mode. The singers who breathe in provoking abnormal contractions which immobilize the midriff, impress very limited movements to the larynx, or keep it motionless even during the ascending scales. On the contrary, during the deep respiratory movements necessary for singing, the larynx moves vertically in the expiration and goes down during the inspiration.

The singer who does not make use of the complete respiration and who, consequently, contracts the midriff so as to recur to the thoracic breathing, is obliged to make an effort which provokes the fixity of the extrinsic muscles of the larynx, throat and jaw; all these contrivances impeding the normal play of the organs of phonation and, consequently, the normal production of the voice.

CHAPTER XI.

ON THE WAY OF PITCHING THE VOICE AND ON ARTICULATION.

How to pitch the voice. A voice which is well pitched yields pure, firm and vibrating tones without any hesitation or trembling, and with an even continuous breath.

A tone is well held, or in Stage language well hooked, on the condition only that the respiration be correct, or more exactly the expiration, as it is the expired air which forms the sound and holds the notes. This is the meaning of the expression « prop upon the breath ».

It is the regular delivery of the sound which gives the note a regular emission, without modification in the variations of both pitch and intensity. During the whole time the sound lasts, it must keep the same homogeneity and the same justness.

To attain this result it is necessary that the groups of similar muscles, which cooperate in setting into motion the organs of phonation, should combine their action so as to determine a power equal in strength and in agility; in other terms, the singer must learn how to govern his larynx, his pharynx and his mouth by means of exercises designed to make them supple, and which will accustom them to make regular movements depending from the will, and free from violence or abrupt effort.

The expired air current must not find a too easy outlet through the glottis, as the pressure, in diminishing too rapidly, would bring the pitch of the tone down; similarly, if the air pressure was forced, the sound would rise.

It is not easy to keep a note absolutely in tone. If the tone is prolonged for a certain time, variations are likely to occur either

above or below the tone; these variations depend from the changes of tension and relaxation of the phonation muscles.

It has been demonstrated in physiology that the muscles do not always stand at the same degree of contraction. If the contraction of a muscle is graphically registered, the line which is obtained is sinuous instead of being straight; this proves the continual variations of the muscle. Such is the case for the larynx.

The note may seem true to a trained ear, even if there is a small difference. In a tone which gives 300 vibrations per second for instance, there can be one vibration more or less; this difference can be of three vibrations per hundred, without the note ceasing to appear true.

Therefore the matter of the air delivery and of the holding of the tone depend from the play of the lungs and the phonation muscles. The lack of tension of these muscles determines the tremolo.

Every singer who has a well pitched voice must therefore set the movement of respiration, in accordance with the production of the tone and with the shape of the cavities of resonance. If these conditions are fulfilled, the voice is powerful and the tones steady, round and sounding; there are no oscillations, nor tremols during the whole time the tone lasts, as may be verified by placing a lighted candle in front of the mouth : if the case is such, the flame does not flicker.

The tone must be released without abruptness, before arriving at the end of the expiration.

Of old, this question was studied thoroughly, and the Italian schools deserved their great reputation, for the pupils have to practise many series of exercises before being allowed to sing any tunes. The secrets of the Italian school have often been extolled, but in reality there was only one secret which consisted in a combination of common sense on the part of the master, and of endless patience on the part of the pupil. In those days, as *Mackenzie* said, the voices were not made like *Peter Pindar*'s razors, just to be sold, but also to be used.

This reminds me of a famous anecdote concerning *Gaetano Mariorami*, surnamed *Caffarelli*, who had undergone the operation of castration upon the advice of his first master *Cafarello*. His second master, *Porpora*, made him practise during six years upon exercices which held in a sheet of music paper. When after that lapse of time, the pupil timidly asked to be allowed to try a tune, the professor answered : « My son, thou art the greatest musician in the whole world. »

Rubini, likewise, did not hesitate to study during seven years before appearing in public.

I wonder if it would be possible to find nowadays, pupils willing to be subjected to the severe discipline of the Roman schools?

Here is, according to *Bontempi*, an account of the work which was required of the scholars of that wonderful epoch :

« The pupils were bound to employ one hour every day in singing difficult pieces, so as to acquire all the necessary experience. Three hours were devoted, one to the trills, the second to the voice passages and the third to the study of runs. During another hour the pupil worked under the direction of the master who used to place a mirror in front of him, so that he should grow accustomed never to make any movement of the eyes, forehead or mouth, while he was singing. These were the morning occupations.

In the afternoon, the theory was studied for half-an-hour; an hour was devoted to the counterpoint or *canto fermo*, another hour to the study of belles-lettres. The rest of the day one practised on the harpsichord or one exercised oneself in the composition of a psalm, of a mottet, of a song or of any other composition according to the pupil's talent. Such were the occupations when the disciples did not go out.

Otherwise, one would go to the Portica Angelica and sing there within call of an echo which, sending back the sound, enabled the singer to judge of his voice, or else one could listen to the music which was played in the churches of Rome.

When they were back again, the pupils had to give their impressions to the master. »

Nowadays this method has changed altogether. The voices, like *Peter Pindar*'s razors, are made only to be sold, according to the formule of one of our tenors who knew fame at a certain moment.

The science of the tuition of the singing elements has been forgotten; a singer is made in a few months; in ten days he has been taught an opera; the making of his stock-plays is the matter of a year. He is pushed on the stage, and after some time the downfall happens, and he realizes then that he ignores everything regarding the elementary principles of which no mention has ever been made to him. Some years ago the pupils practised for an hour, now scarcely five minutes are granted to the study of exercises! Dancers, boxers, and generally all the people who have a profession which requires physical training, appear in public the day only they feel absolutely fit : can one say the same of singers? How many can even boast of having made a decent career?

Such is the cause of the decline in the art of singing.

Yet it is easy to see when the voice is wrongly pitched and the tone unsteadily held, as will be shown in a further chapter on the control of the voice.

Pacherotti's counsel is actually ignored : « Pitch your voice in a true manner and pronounce distinclty, and your singing will be irreprochable. »

Articulation. — Pronounce distinctly, this implies that the organs, and specially the tongue, must be disposed so that each vowel takes birth at the approximate spot where its generative orifice has to be placed. I have sufficiently enlarged upon the subject.

Under an erroneous pretext, the singing-master ignoring his art advises his pupils to alter the vowels while singing, and to change *a* in *o*, and *é* in *i*. He shifts the organs and is unaware that he, thereby, modifies for the worse the emission of the voice. Certain teachers go as far as to prevent the movements of tongue by keeping it flattened against the bottom of the mouth by means of some instrument. If the tongue cannot come in close enough approximation with the roof of the palate, to form the narrowing (generative orifice of the tone) which is necessary for the utterance of the vowel, the latter cannot be produced, as may be easily observed by keeping the tongue down, with a paper-knife for instance. Others teachers put into mouth instruments of torture designed to press the soft palate back. Everybody has heard of the use which is made of india-rubber balls, which have to be kept in the mouth for the sake of improving the articulation. What else could one invent to try and annihilate the natural function of the organ of phonation!

More than two thousand years ago the Hindoo priests brought the utmost care into the study of the movements of speech. This is expounded in the Books of the Vedas : « the Praticakhya ».

This perfectness in the analysis of the mechanism of speech was born in these Orientals from a religious idea; they considered a defective pronunciation of the holy texts as a profanation, and had subjected the articulation of the sounds to severe laws.

The Romans too attached a great importance to oratorial art. *Quintilian* demands that each word be articulated in such a way that every letter should retain its particular tone; he enjoins not to twist the lips and to open the mouth too wide.

In the XVIth century, *Emilio del Cavalieri* proclamed that music grew annoying when the words could no more be heard.

« An exact, precise and regular pronunciation is the first condition of the song with words. It is therefore necessary to begin by learning to speak well, if one is desirous to excel in this art. The beauty of gesture, the richness of a brilliant vocalization, the charm of an expressive physiognomy, the peals of a sounding and melodious voice are unable to mask the flaws of a defective pronunciation.

Tosi writes : « For lack of a good pronunciation, the singer

deprives his auditors of the charm which the words add to the song, and suppresses both truth and strength. When the words are not distinctly heard, one is unable to make the difference between human voice and the tones of a hautboy or of a cornopean. This defect, which is very detrimental for the singers and prejudicial for the execution, is practically universal nowadays. Yet the singers ought to be aware that it is the words which place them above the instruments. »

In his turn *Framery* makes our French women singers the reproach of neglecting to make the words heard, and to mangle them too often for lack of grasping what they mean. He adds : « The finest tune of which it is impossible to hear the words is but a voice sonata, and it is vainly that the musician will have endeavoured to give expression to feelings, if the auditor is only made judge of some vague sounds. »

It is not rare to hear nowadays singing-masters give their pupils the advice of moving neither lips nor tongue, or else to hold the soft palate raised. How is it possible to articulate under those conditions?

Mr. *L. Brémont* is perfectly right in saying that the singing-masters who are not very particular regarding articulation are not worthy of teaching. He writes : « Out of one hundred singing-scholars hardly one third articulates sufficiently. Of none can be said that he articulates too much. »

And yet how attentively does one not listen to the singer who articulates well. This distinctness of pronunciation was the chief quality of *Noté*, who was always greatly appreciated by the public who never lost one single word he uttered.

Who remembers still the wonderful articulation of *Miolan-Carvalho, Galli-Marié, Faure...*, to name only some departed.

And Mr. *Brémont* judiciously observes : « There has never been, there will never be, there cannot be any real great artist without articulation. »

CHAPTER XII.

ON THE REACH OF THE VOICE.

The reach of the voice does not depend exclusively on the breath. The singer who, gifted with good resonances, brings out the tune or, according to the expression used by the Italian singing-masters of old, « sings on a level with the lips » without unnecessary expense of breath, will easily succeed in making himself heard by all his auditors, if he keeps in mind that he addresses the people placed in the farmost parts of the room.

Generally the teachers fashion the voice of their pupils so as to suit it to the room in which they sing habitually, without thinking that when they will be called to sing in a larger place, they will require greater resonance and intensity. It is the reason why the teachers advise their pupils who are going to sing in public to force their means and the consequence is a bad audition.

« When the pupil is methodically trained for the stage, the emission of the voice must be complete and the timbre fully rounded. The articulation must be normal, and the least shades of expression and articulation well set off. In a room of small proportions and muffled by furniture, the result created is a declamatory aspect and an animation, the vivacity of which seems exaggerated to those who are not accustomed to stage effects. But when the pupil leaves the school for the stage, nothing has to be altered to his system; the only counsel one can give him is to keep entirely to his means and his habits. » (*Bonnier*).

Intonation. — Intonation is the average pitch of the spoken voice or, in other words, the note on which one speaks as a rule. It does not depend from the timbre, for several people can have the same intonation without having the same timbre of voice. It is higher in children than in adults, and in women than in men.

It can also vary for the same individual; the voice is deeper in the morning when one gets up than later in the day. This

peculiarity can be observed in the case of certain artists, I will only cite the instance of a barytone whose tessiture goes from *Sol*[1] to *Mi*[3] in the morning, whilst in the evening it extends from *Si* ♭[1] to *Sol*[3], as the registration of his voice has proved most clearly. Besides it is very customary to hear an artist say that he could not possibly give a performance in the morning.

If one speaks in preference on a certain note, it is nevertheless true that, unless the voice be monotonous, it is carried during the course of conversation over a scale of from two to five notes, or exceptionnally an octave, as may be also easily ascertained by means of the graphs of the spoken voice.

The people of the south, the orators, the tragedians change even sometimes of tone in the range of an octave, but nevertheless they have recourse in preference to a note which recurs more frequently than others, when they speak naturally without trying to vary their language; this note is the one which determines the normal intonation.

The best intonation for speaking in public is the ordinary intonation; it is a dangerous proceeding to choose for speaking an intonation which is either too high or too low. One does not acquire thereby a louder voice and one does not speak with more solemnity, but one risks causing a fatigue of the organs, detrimental to the production of the voice. The latter loses its original purity and, in spite of the speaker's efforts, grows smaller gradually till it ends by breaking and provoking hoarseness.

One must avoid beginning to recite in too loud a tone which obliges the speaker as he goes on to lessen his voice, for in that case the words become finally indistinct.

One must hold the golden mean. « The medium tones of the voice, had already wrote *Quintilien*, are preferable to any other, reserving to make them thinner or to alter them according to the requirements... The voice must not be forced, as by doing so one stifles it; the effort renders it less clear and makes it appear to be choked. » The Greeks designated the sound thus produced by a name which reminds us of « the cry of the cocks still unable to sing ».

The speaker must vary the effects and the intonations of the voice; he must give it different inflections according to the feelings he has to express and, above all, avoid monotony which not only is a real torture for hearers, but also engenders the exhaustion of the voice. *Talma*, to be sure of having a normal intonation, used to ask the first comer, before coming on the stage, by way of having the proper diapason : « Sir, would you kindly tell me the time? » And when the answer had been given to him in an ordinary tone, he would add : « Thank you, Sir » and the great tragedian, in going on the stage, would utter his first words in the tone he had just taken to pronounce : « Thank you, Sir. »

The normal intonation, with very few exceptions, takes place in thick register, even in women.

« Basses seem to speak on *Mi*^{2}, like *Isnardon,* whose chest register goes from *Fa*♯^{1} to *Fa*♯^{3} and head register to *Ut*^{4}; barytones on *Mi*^{2}, like *Soulacroix* whose register ranges from *La*^{1} to *Si*^{3}, and head register to *Mi*^{4}, or on *Fa*^{2} or *Sol*^{2}, like *Fugère* whose thick register extends from *Sol*^{1} to *Sol*^{2} and thin register to *Mi*^{4}; and tenors on *Sol*^{2}, like *Mouliérat* who is in possession of a chest register going from *Ré*^{2} to *Si*^{3} and a thin register which reaches *Mi*^{4}, like *Degenne* whose chest register goes from *Ré*^{2} to *Ut*^{4} and lower thin to *Mi*^{4}, or on *La*♭^{2} like *Herbert* whose thick register is carried from *Ut*^{2} to *Ut*^{4}, and thin register to *Mi*^{4}, or else *La*^{2}, like *Barnolt* whose chest register ranges from *Fa*^{1} to *La*^{3}. »

« Therefore the normal intonation is not placed at an equal musical distance between the deeper and the shriller tones. » (*Lermoyez.*)

Let me add that it comes nearer the beginging of the tessiture.

Researches have been made by *Flatau* and *Gutzmann* regarding the shricking voice of newly born, and they have come to the conclusion that it stayed very close to *La*^{3} (435 d. vibr.). *A. Barth* and *Gutzmann* have found that in adults the ordinary tone varied from between *La*^{1} (108 d. vibr.) and *Mi*^{2} (163 d. vibr.) for men, and from between *La*^{2} (217,5 d. vibr.) and *Mi*^{3} (327 d. vibr.) for women.

Quantity of energy necessary for the production of the tone. — We have previously seen that the bucco-pharyngeal cavities could raise the pitch of the tone, in consequence of a vortex arriving at a greater speed, owing to the increase of the pressure of the expired air current. Similarly small mouths can render sounds which are so much the deeper that the cyclones are slower, thanks to a feeble pressure of the air current.

Thus, to produce the same tone, a child does not need to furnish as great a pulmonary effort as an adult who has a larger mouth.

It is also the reason why women, with a smaller pulmonary capacity than men, are able to hold a note for quite as long as a bass or a tenor.

Thus the small cavities have over larger ones the advantage of having a lesser effort to make, and consequently they are less exposed to pulmonary fatigue and can work longer.

The composers seem to have taken this observation into consideration, as, generally, the basses' parts are less full than tenors'. It is the women, and specially the soprani, who are given the greater number of notes to sing.

For a deep note, more breath and pulmonary work are required than for a brilliant series of high and shrill notes.

When a singer tires himself in the course of a performance, the deep notes are the first to disappear. The shrill notes can still be sung loudly, when the deep ones seem to be stuck up in the throat.

The amount of work developed by the vocal apparatus during the phonation has been measured.

In general, the adult breathes sixteen times per minute at the most, that is 960 times per hour, with an average pressure of 34 millimetres of water. With each respiration 500 cubic centimetres of air are rejected and then brought in, this makes, for a complete respiration, 16 litres per minute, or 950 litres per hour or, in round figures, one cubic metre.

The formule $T = VH$ answers the question, V, being the volume of air which passes trough the lungs in a given time under a pression H; T being the energy.

$V =$ one cubic metre per hour, one will have $T = H$, which means that the work of the lungs in kilogrammetres, and the pulmonary pressure in millimetres of water, are expressed by the same number, whence the respiration, which corresponds to 34 millimetres of water, develops a work of 34 kilogrammes per hour, and the ordinary language, which corresponds to 16 cubic centimetres, develops 160 kilogrammes [1].

Thus the figure : 160 kilogrammes per hour represents the work during an hour, on the condition that the utterance be constant. But one does not sing during the inspiration; furthermore the artist prolongs the delivery of his expiration, which instead of being of 1/16th of a minute reaches the fourth, and even sometimes the half, and finally one must reckon with the times of rest during this hour's work.

Let us increase the above given figure, and say 180 kilogrammes per hour; this will make 3 kilogrammes per minute or 1/20th of a kilogramme per second; therefore the artist, when he sings, raises at the utmost a weight of 50 grammes at the height of 1 metre per second.

Women, whose pulmonary capacity is less than men's, will therefore tire themselves less, as aforesaid.

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[1] For the singing on a moderate key, *Cagniard de Latour* has found a pressure of 160 millim. of water and, on a higher key with the same loudness of voice, a pressure of 200 cubic millimetres.

CHAPTER XIII.

EXPERIMENTAL CONTROL OF THE VOICE.

The graphic and photographic methods by which means one registers the vibrations of the voice and the movements of the various organs which contribute in forming and producing the tone, enable us to ascertain if an artist sings in tune and without any effort, if his — or her — voice is well toned, if the movements of the larynx take place with method, if the generative organs of the voice are adapted so as to deliver the required tone, etc.

The easiest way of measuring the three elements of the voice: pitch, loudness and timbre, is to register the tone by means of *Lioret*'s apparatus which gives enlargements of three hundred times vertically, and of three times and a half horizontally [1].

Figure 120.
Graph of the reed tuning-fork La^3.

Pitch of the tone. — To find out the pitch of the tone, one measures the number of periods [2], or double vibrations, which corresponds to this note in one second [3].

The tuning-fork La^3 (normal diapason) effects 435 periods per second. It is easy to ascertain that the length of the above graph

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[1] The small registering roller of the phonograph proceeds at the rate of two turns and a half per second, or 100 turns per minte. In the developing upon the paper band, a length of 61 centimetres represents one turn of the roller. (The apparatus I am using has been established on this basis, but the speed of the phonograph can be altered at will.)

[2] Let us bear in mind that the period is the complete form of the vibration regularly repeated.

[3] *J. Baratoux. — On the scientific tuition of singing.* Scheme addressed to the under-secretary of State for Fine Arts, with the return of the Comission appointed to this effect. Paris, 1917.

Periods	Notes	Length of the outline	Periods	Notes	Length of the outline	Periods	Notes	Length of the outline
1044	*UT*^{5}	1,458	610		2,495	350		4,35
1040		1,463	600		2,537	348	*FA*^{3}	4,375
1030		1,478	590		2,581	345		4,413
1020		1,492	587,25	*RÉ*^{4}	2,592	340		4,477
1010		1,507	580		2,625	335		4,544
1000		1,522	570		2,67	330		4,613
990		1,537	560		2,718	326,5	*MI*^{3}	4,666
980		1,553	550		2,768	325		4,684
978,75	*SI*^{4}	1,555	543,75	*UT*♯^{4}	2,8	320		4,757
970		1,569	540		2,819	315		4,833
960		1,585	530		2,872	310		4,911,29
950		1,602	522	*UT*^{4}	2,916	305,859	*RÉ*♯^{3}	4,977
940		1,619	520		2,927	305		4,981
930		1,637	515		2,956	300		5,075
920		1,654	510		2,985	295		5,161
910		1,673	505		3,014	293,625	*RÉ*^{3}	5,185
906,25	*LA*♯^{4}	1,668	500		3,045	290		5,25
900		1,691	495		3,075	285		5,342
890		1,7105	490		3,107	280		5,437
880		1,733	489,37	*SI*^{3}	3,111	275		5,536
870	*LA*^{4}	1,75	485		3,139	271,875	*UT*♯^{3}	5,6
860		1,770	480		3,171	270		5,638
850		1,791	475		3,205	265		5,745
840		1,811	470		3,239	261	*UT*^{3}	5,833
830		1,834	465		3,274	260		5,855
820		1.856	460		3,309	255		5,975
815,62	*SOL*♯^{4}	1,866	455		3.346	250		6,09
810		1,879	453,125	*LA*♯^{3}	3,36	245		6.214
800		1,903	450		3,383	244,875	*SI*^{2}	6,312
790		1 927	445		3,421	240		6,343
783	*SOL*^{4}	1,944	440		3,466	235		6,478
780		1,957	435	*LA*^{3}	3,5	230		6,619
770		1,977	430		3,540	226,562	*LA*♯^{2}	6,72
760		2,003	425		3,582	225		6,766
750		2,03	420		3,622	220		6,920
740		2,657	415		3,668	217,5	*LA*^{2}	7
730		2,685	410		3,713	215		7,081
725	*FA*♯^{4}	2,1	407,82	*SOL*♯^{3}	3,733	210		7,25
720		2,114	405		3,759	205		7,426
710		2,144	400		3,806	203,906	*SOL*♯^{2}	7,468
700		2,175	395		3,854	200		7,612
696	*FA*^{4}	2,187	391,5	*SOL*^{3}	3,888	195,75	*SOL*^{2}	7,777
690		2,206	390		3,903	195		7,807
680		2,238	385		3,954	190		8,013
670		2,273	380		4,006	185		8,229
660		2,306	375		4,06	181,25	*FA*♯^{2}	8,4
652,5	*MI*^{4}	2,333	370		4,114	180		8,458
650		2,342	365		4,171	175		8,7
640		2,378	362,5	*FA*♯^{3}	4,2	174	*FA*^{2}	8,15
630		2,416	360		4,229	170		8,955
620		2,455	355		4,288	165		9,227
611,718	*RÉ*♯^{4}	2,488				163,125	*MI*^{2}	9,337

Figure 121.
Table of the length of the periods for each note.

(Fig. 120) is 3 millimetres, 5 for one period, which gives a length of $435 \times 3{,}5 = 1522$ mm. 5, or 1 metre 52 centimetres to the graph per second, viz. : 15 cm. 22 per 1/10th of a second.

To find out the length of the periods which correspond to each note of the scale ,one divides the number 1522,5 representing the length of the graph per second, by the number of periods [1] corresponding to the given note. One can establish thus the foregoing table for each note of the tessiture.

To know if a note is in tune, one measures on the graph the length of one period or, better still, of ten periods so as to make the reading of the decimetre easier, and one compares the length thus obtained by the length inscribed on the table in regard to the note concerned.

I am giving below the graph taken on a soprano, from the Paris Opera, who was singing *A* on *La*³.

Figure 122.
Graph of *A* sung on *La*³.

As the period corresponding to *La*³ is of 435, by dividing 1522,5 by 435, one obtains the length of the period (3,5) which must be found on the graph, if the note is in tune : this is indeed the figure obtained by measuring the period of the graph, therefore the note has the right pitch.

By making use of the table a quicker result is obtained, as it suffices to read the length of the period found on the graph, and to see if the number thus read is the one corresponding to the note which has been sung.

If all the periods of the graph are equal in length, as in Figure 123, it is a sign that the note is well held.

The graph of this note which is well held, according to the pitch of the tone, can be represented by a straight line :

*La*³ (435) ----------

Figure 123.
Graphic of the graph of *A* sung on *La*³.

The following graph (Fig. 124) shows *O* sung on *Ré*³ (493,62).

*Ré*³ has a length of period of 5 millimetres 18. If one measures the graph, one finds for the first part a length of 5,3 millimetres, cor-

[1] Or double vibrations.

responding to 285 periods; for the second part, a length of 5,5 millimetres corresponding to 275 periods, and for the third part, a length of 5 millimetres, corresponding to 285 periods.

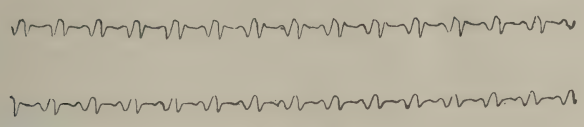

Figure 124.
O sung on *Ré*³.

The graphic of this graph will be represented by a broken line.

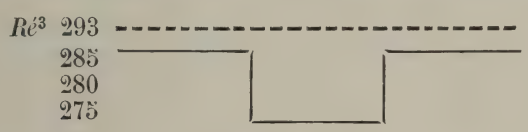

Figure 125.
Graphic of the graph of *O* sung on *Ré*³.

It is evident that the note is not properly held and that the voice is wrongly pitched. Furthermore the note is uttered below the required pitch.

In the following graph (Fig. 126) showing *O* sung on *Mi*³ (326,5) it is to be noticed that the lengths of the periods are respectively 4,85 (315 per.), 4,7 (320), 4,8 (315) and 4,6 (326,5).

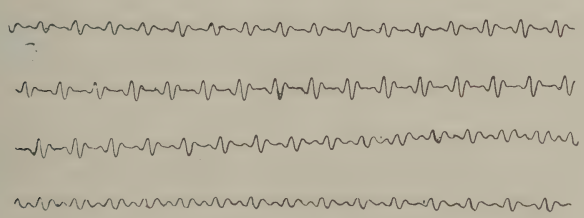

Figure 126.
O sung on *Mi*³.

The graphic of this outline is represented by an ascending broken line, which reaches the normal height of the note in its latter part only.

Figure 127.
Graphic of *O* sung on *Mi*³.

The note has been delivered below the tone.

In the following graph (Fig. 128), representing *E* sung on *Sol*³, (391,5) the opposite defect is apparent.

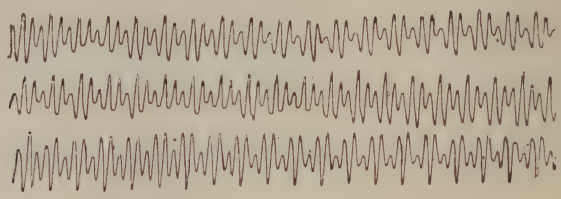

Figure 128.
E sung on *Sol*³.

The measurements obtained successively on the periods are : 3,5 (435 per.), 3,6 (415), 3,65 (415), 3,75 (405), 3,8 (400), 3,85 (391,5) ; this proves that the note has been taken above the tone, which has been correctly reached on the last part of its production.

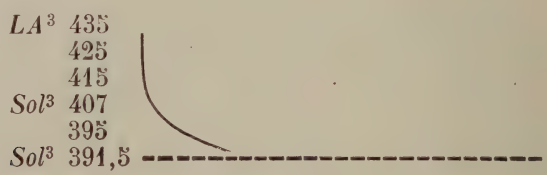

Figure 129.
Graphic of *E* sung on *Sol*³.

In the foregoing graphs, the pitch of the tone is characterized by the dimension of the period in the horizontal direction.

Intensity of the tone. — The intensity of the tone is indicated by the dimension of the period in the vertical direction.

If during the whole production of the tone, the intensity has kept absolutely even, the various vertical lines of the period must be regular and measure the same height (see Figs. 53 and 61, pp. 79 and 85).

Tremolo. — The following graph of *A*, *I*, *A*, sung on *La*^{3} (Fig. 130) is a striking example of irregularity in the intensity of the tone, it is a characteristic type of tremolo.

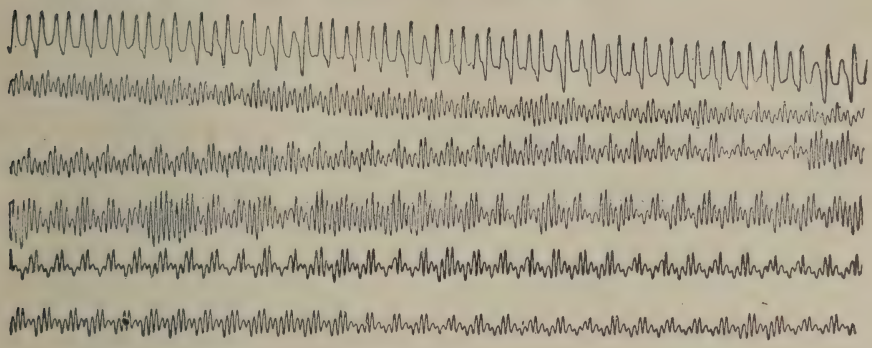

Figure 130.
A, *I*, *A*, sung on *La*^{3} (type of tremolo).

Timbre. — As for the timbre it is represented by the shape of the sinuosities (or, in other words, of each of the inflexions which compose the period) and by their relative number, duration and intensity of these sinuosities.

I am giving here two graphs of *I* sung on *Ut*^{3}; the first one (Fig. 131, *a*) is well toned, but not the second (Fig. 131, *b*).

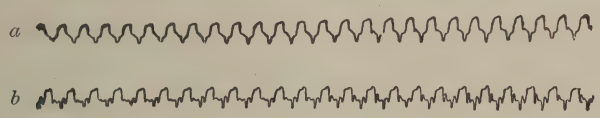

Figure 131.
I sung on *Ut*^{3}. — *a* well toned. — *b* badly toned.

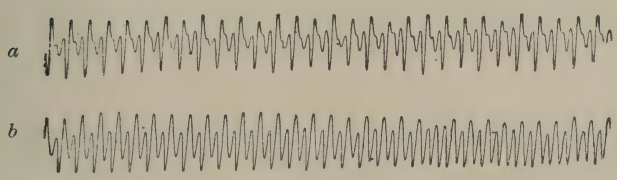

Figure 132.
A sung on *Ré*^{4} (a) and on *Mi*^{4} (b).

Tessiture. — It is easy to get an exact appreciation of the tessiture by means of the registration of the notes placed at both extremities. As long as the graph of the notes present sinuosities of regular length and height, and details as to the shape of the period (Fig. 132, *a*), the voice can extend up to these notes; but it

is a different matter if the graph is a sinusoïd and if the note is no longer just, as may be seen from the length of the period, or even if the intensity is irregular as the reading of the period, considered in the vertical direction of the graph, gives evidence (Fig. 132, *b*). Therefore one must avoid making the pupil practise on these last notes, at least in the beginning.

Attack of tone. — In the following graphs (Figs. 133, 134, 135) are represented the different ways of attacking the note :

1. *Attack on the breath* (*weak attack*). — In this instance the graph gives the real shape of the period only after a certain number of twentieths of a second (Fig. 133).

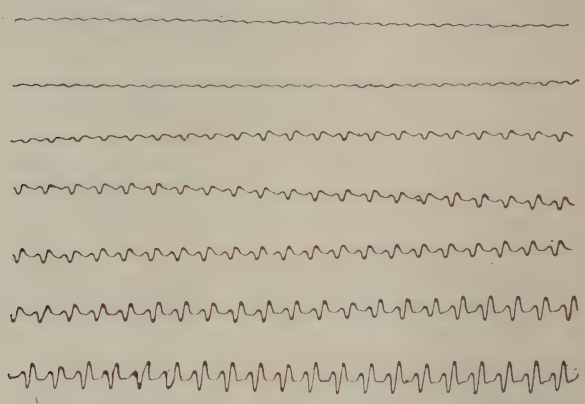

Figure 133.
Attack on the breath, or weak attack.
(Eeach line of the graph represents 1/20th of a second.)

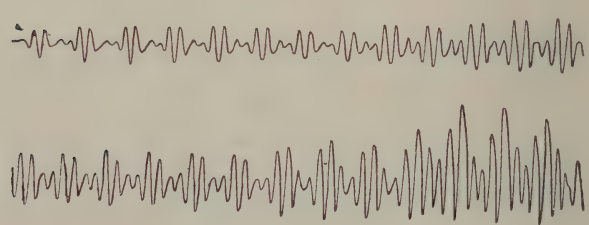

Figure 134.
Attack by forced shock of the glottis, or abrupt attack.
(Each line has a durationof 1/20th of a second.)

2. *Attack by forced shock of the glottis* (*abrupt attack*). — The graph proves that the effort of the expiration has borne upon the period : the intensity is irregular (Fig. 134).

3. *Direct attack* (*normal attack*). — After a few periods at the utmost, the graph is normal (Fig. 135). The vocal cords to let the breath pass make a slight explosion, similar to the explosion of the lips during the production of the consonant *p*.

Figure 135.
Normal attack of the note.

Trill. — The graphic method gives valuable information as regards the execution of the trill.

Here is the graph of a trill executed on La^3 (435) (Fig. 136).

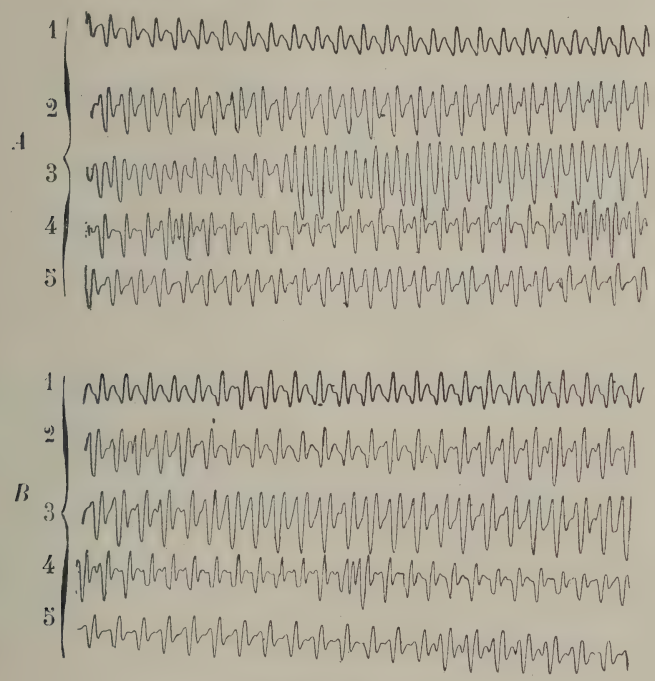

Figure 136.
All the corresponding lines of *A* and *B* are the continuation of each other : for instance the line *B*, 1, is the continuation of *A*, 1, etc....

Trill : A executed on La^3.
As the graph of this trill measures 8 metres in length, I am giving here a part of it only. The length of each line represents 1/20th of a second.

Faure has given of the trill the following definition : the trill consists in a rapid and regular beating of the note on which it has

been placed with the next note situated at an interval of a tone or a semitone above.

If the trill had been sung normally, it would have been executed on the notes *La*³ (435) and *Si*³ (489,37). It would be represented graphically by the dotted line shown in Figure 137.

But this is not the case. On the part of the trill which does not figure here, and which corresponds to the beginning of its production, the note has been attacked correctly but has risen rapidly and reached *Ut*⁴. Therefore the trill has been badly executed.

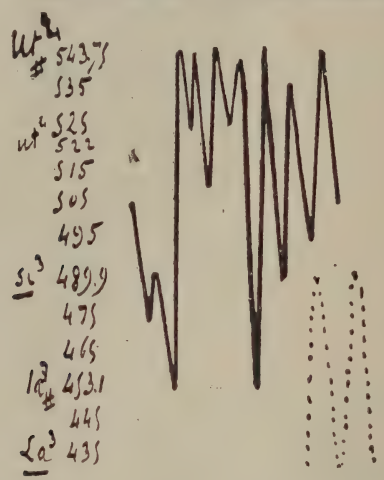

Figure 137. Graphic of the previous trill.
The black line shows the trill as it has been executed.
The dotted line indicates in what way it ought to have been executed.

Example of a graph. — The following graph has been taken on a young girl, a soprano, who is destined to the theatre. During two years consecutively she has taken singing lessons, but she has noticed, since a few months, that her voice faltered, that she felt some fatigue when she had been practising, and that she was even becoming aphonous. I have made her sing the vowel *A* before a phonograph on the notes *Do*³, *Mi*³, *Sol*³, *Do*⁴, *Mi*⁴ and *Sol*⁴, I have obtained the following results with *Lioret*'s apparatus :

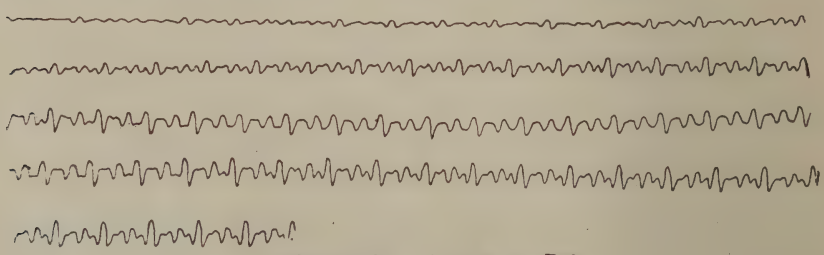

Figure 138. *A* **sung on** *Do*³.

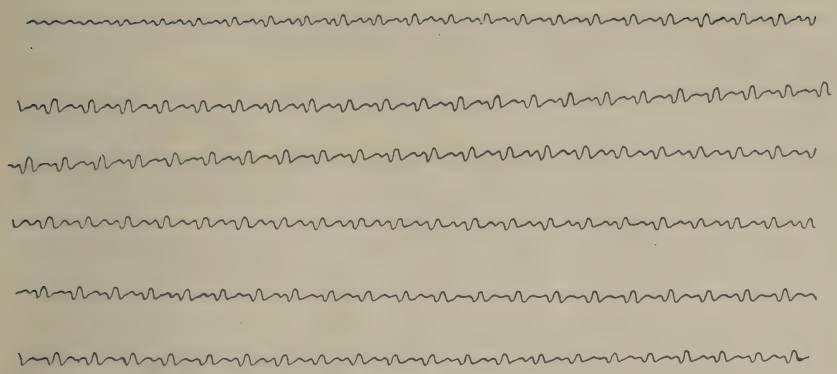

Figure 139. *A* sung on *Mi*[3].

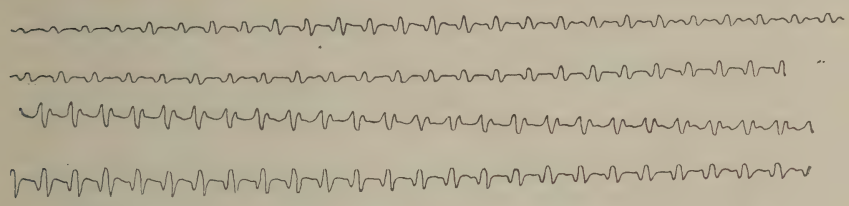

Figure 140. *A* sung on *Sol*[3].

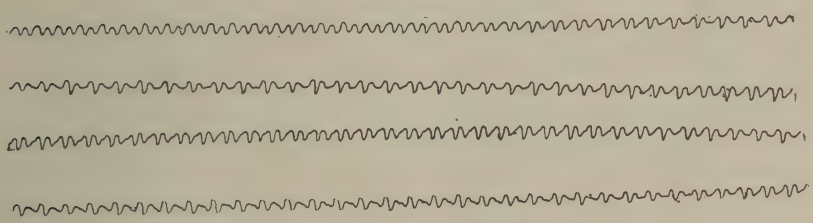

Figure 141. *A* sung on *Do*[4].

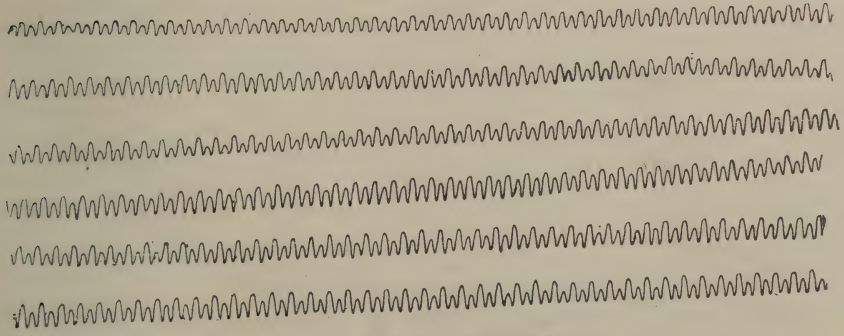

Figure 142. *A* sung on *Mi*[4].

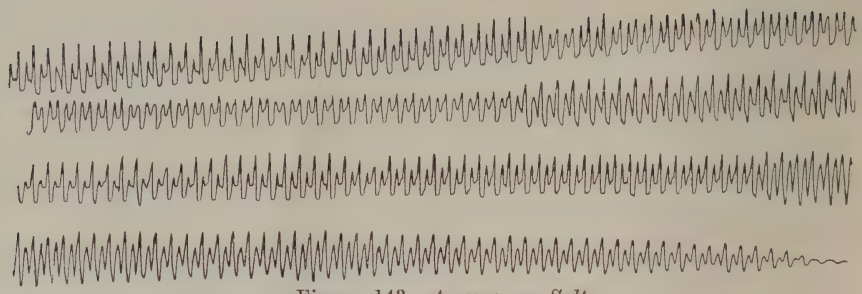

Figure 143. *A* sung on *Sol*[4].

It is indispensable after each registration on the phonograph to take also the registration of the reed tuning-fork *La*[3] (435 per.) so as to know if the length of the period is in accordance with the one recorded on the table (Fig. 120, p. 160) and to make sure thereby that the apparatus works regularly, as the changes of temperature can influence in some way the wax of the roller (Fig. 144).

Figure 144. Graph of the reed tuning-fork *La*[3].

If one measures with a centimetre the graph of the tuning-fork, one observes that each period is 3 centimetres 5 long, this figure corresponds exactly to the number 435 inscribed on the table, therefore this graph is correct.

The length of the periods of each note delivered by the soprano has now to be measured. If one considers the different periods of the graph of *Do*[3] (261 per.) one observes that each of the successive measurements which have been taken, are below the normal figure, as they give in turn : 230, 220, 250, 240 periods corresponding to the lengths 6,61, 6,92, 6,09 and 6,34 of each of the periods of the graph, instead of the figure 5,833. We can therefore establish the following graph (Fig. 145).

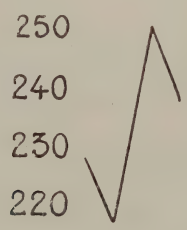

Figure 145. Graphic of the graph of *A* sung on *Do*[3].

The note has been taken too low; it has even at a time been sung on *La* ♮ [2], has hardly passed *Si*[2] and has never reached *Do*[3].

For *Mi*[3] (326 per.) we find successively for each period of the

graph : 305, 305, 315, 315, 290, 310, 310, 310, 315, 315, 310; therefore the note never passes beyond *Ré*³ (305 per.), a fact which is expressed by the following graph (Fig. 146).

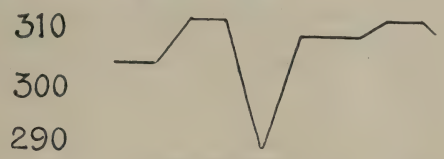

Figure 146.
Graphic of the graph of *A* sung on *Mi*³.

For *Sol*³ (391,5 per.), the measure of each period of the graph gives the following figures : 360, 350, 345, 370, 380, 370, 350, 360, 350, 360, 370, 350, 345 (Fig. 147).

Figure 147.
Graphic of the graph of *A* sung on *Sol*³.

By proceeding in the same way for *Do*⁴ (522 per.), one finds successively for each period the figures : 540, 520, 520, 505, 505, 490, 490, 490, 500, 475, 475, 490, as indicated in the graph below (Fig. 148).

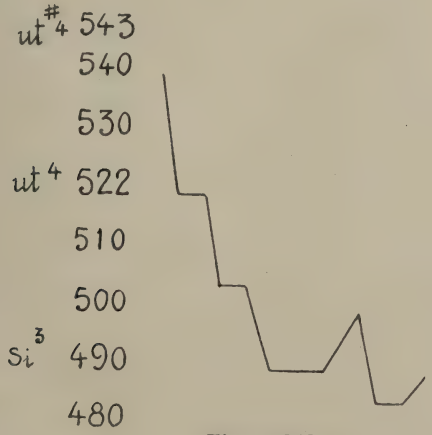

Figure 148.
Graphic of the graph of *A* sung on *Do*⁴.

The singer has given a note which passed *Ut*[4], which she had to sing, and has gone below *Si*[3].

If one considers the measurements of each of the periods of *Mi*[4] (652 per.), one finds : 600, 630, 630, 630, 600, 630, 630, 600, 630, 600, 600, 630, 630, 630, 600, 630, 600, 600, 630. The note has been delivered on *Ré* ♯[4] (611 per.) and has hardly ever gone higher (Fig. 149).

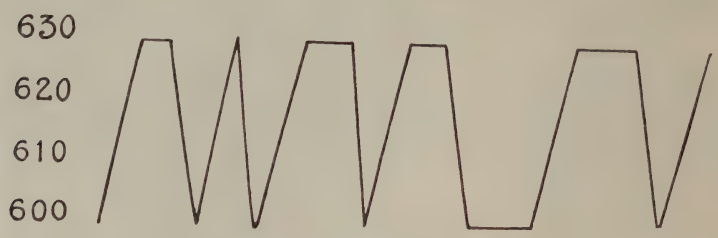

Figure 149.
Graphic of the graph of *A* sung on *Mi*[4].

For *Sol*[4] (783 per.), the figures obtained successively are : 760, 760, 760, 760, 760, 760, 760, 760, 725, 760, 760, 760, 760, 760, 760, 760, 760, 725, 760, 760 (Fig. 150).

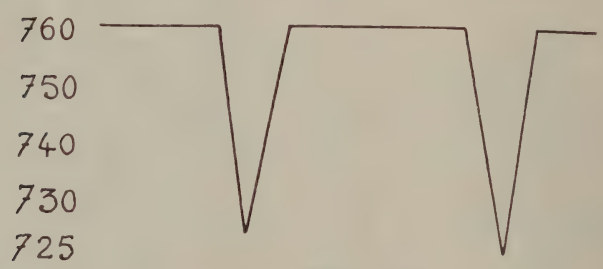

Figure 150.
Graphic of the graph of *A* sung on *Sol*[4].

The note has been sung at a nearly constant pitch, but below *Sol*[4].

Thus, the note has never reached the normal number of periods, the breath has not been powerful enough to raise the tone up to the normal height; this is the proof of a defective breathing. The note is not in tune, it is not well held, the figure resulting from the measurement of each period being variable, and lastly the intensity is irregular, as appears from the height of the graphs of each down stroke of the period. It is furthermore easy to remark that the timbre is not satisfactory in the high notes, the inflexions of the graph for each period being irregular and variable in number, duration

and intensity. Besides, the voice quavers, as is proved by the examination of the height of the graph of the different periods.

The following conclusions can therefore be drawn : the voice is bad, tired and lacks evenness and breath; the respiration is defective; the training of the voice must be begun over again after a few months rest.

This data furnished by the phonographic graph have been confirmed by two competent personalities : a singing-master and a lyric artist, before whom this pupil has been made to sing.

CHAPTER XIV.

ON ACOUSTICS IN PLAY-HOUSES.

In general the artists do not take heed of the room in which they are called to sing, though this is a matter of great importance for the production of the voice.

Some years ago, during the course of a conversation I was having with the architect of the Paris Opera : *Charles Garnier*, I was surprised to hear him say that when he built that house, he followed no rule whatever regarding acoustics for the reason that, according to him, there was no such rule concerning the erection of a theatre!! Unhappily chance has served him rather ill, for it is an obvious fact that from the last row of stalls, the prompter can be heard giving the cue to the artist. Let me add that the places which are considered as being the best, as regards acoustics, are in the lateral boxes of the last floor, from where it is impossible to see the stage.

Likewise in the former Opera-Comique, one could not help noticing from the first side stalls a deafening noise, produced by the music.

In the Trocadero, the acoustics of the play-house is very bad indeed. The artists who are accustomed to sing there know that somewhat on the right hand side of the protruding part of the scene, there is a spot where an echo is produced to the great discomfort of the audience. This defect has been partly remedied by means of felt panels, which have been placed behind the organ of the stage.

The ancients were not quite as ignorant as the present architects in the art of building theatres, and the Greek and Roman stages were reputed for their acoustics. The requirements of a play-house are such that the auditors may perceive, at the same time, the direct waves and the waves reflected by the wall, resonance, echo, absorption, stifling of the voice being avoided.

If the sound is of short duration and if the shape of the hall favours a system of regular reflection, a series of distinct echos will be heard.

If the room, on the contrary, gives rise only to irregular reflections or diffusions, there will be no distinct echos, but an increase in the intensity of the sound and a simple prolongation of its duration, the length of which depends on the reflecting power of the walls and the furniture of the room.

An american engineer, Mr. *Wallace C. Sabine*, has made, at Boston, a series of experiments which prove the accuracy of these data. To this effect, use was made of an organ, the pipe of which the Ut^3, put into action by a silent water set of bellows, produced a rather loud tone. When the bellows were stopped suddenly, the sonorous impression did not cease immediately, but was prolonged and lasted during a certain time which Mr. *Sabine* wrote down. He has in that way come to the conclusion, that the duration of a tone of resonance, or *residual tone*, was expressed by the formule :

$$t = \frac{k}{a + x}.$$

The coefficient K is a constant which is in ratio to the volume, V, of the room. It is equal to 0,171 V; a represents the absorbent power of the empty hall; x, the surface of the various absorbents contained in the room. Thus the duration, t, of the residual tone, is expressed by the formule :

$$t = \frac{0{,}171\ V}{a + x}.$$

The best acoustics seem realized in rooms of which the residual tone has a duration of from 2 to 2 1/2 seconds.

The architect who builds a play-house, must not make the mistake of copying the rooms where the acoustics are reputed to be good, and simply amplify them, without taking into consideration the possible increase of volume, or of the change in the building materials and the furniture.

Mr. *Sabine* has drawn the following table, the unit taken being the absorbent power of an open window measuring 1 square metre.

1. *Absorbent power of mural surfaces.*

Open windows	1
Hard pine casing	0,061
Plaster set on wood frame	0,034
» » » wire	0,033
Glass	0,027
Plaster set on tile	0,025
Bricks joined with Portland cement	0,025

2. *Absorbent power of the audience.*

Hearing per square metre	0,96
» » person	0,44
» » woman apart	0,54
» » man apart	0,48

3. *Various articles.*

Oil painting	0,28
Carpets, mats	0,20
Oriental carpets	0,29
Cretonne	0,15
Curtains	0,20
Facing made of floche of horse-hair	0,78
Cork 2 cent, 5 thick, placed between the walls	0,16
Linoleum flooring	0,12

4. *Seats and Cushions.*

Seats made of full ash	0,039
» each	0,0077
» stuffed in horse-hair and leather	0,28
Horse-hair cushion for each place	0,21

Before singing in a room with which he is not acquainted, the artist must remember that the velocity of sound being 333 metres per second, and the duration of a syllabe 1/5th of a second, the distance travelled by the sound during its production will be 333 : 5 = 65 metres; therefore, if the sound is reflected from a point placed at a nearer distance than 32 metres (the voyage thence and back of the sound being taken into account) there is a superposition of the direct and the reflected sounds, and consequently no echo.

If the room is low of ceiling and furnished with hangings, the sound will be easily absorbed. The singer must also be aware that the spectators have a considerable power of absorption, a fact which is noticeable in a theatre when the rehearsals take place in the empty house.

The voice carries well, if the artist hears it sounding slightly at his ear.

CHAPTER XV.

ON THE CONDITIONS WHICH ALTER THE VOICE.

In children, the range of the voice varies according to the sex; this has been observed by *Vierordt* who has made interesting researches on the subject.

In girls, at the age of six, the voice consists of nine tones; at seven, of ten tones; between eight and ten, of thirteen tones; at eleven, of fourteen; and from twelve to thirteen, of sixteen tones.

Thus from between six to thirteen, the voice gains four tones in thick, and two tones in thin register.

In boys, between the age of eight and fourteen, the voice has only a compass of from seven to nine tones.

But this voice compass changes again with age and sex.

Breaking of the voice. — Until puberty the larynx is small; but at that time the vocal apophysis of the pyramids form themselves, the antero-posterior diameter of the larynx increases in boys, the Adam's-apple forms a prominence, the vocal cords grow in volume and in breadth, the pyramids themselves thicken and the ventricles develop : the voice breaks.

The larynx passes suddenly from 15 to 25 millimetres in boys, and from 15 to 20 millimetres in girls.

This transformation can last during a period which varies from between a few weeks up to one year; all the while the voice is hard and covered.

In men, the voice can be carried an octave down and even an octave and a half. However it is impossible to say that the child, which possessed a soprano or an alto voice, will acquire a tenor

voice or a bass, for at that time it is not seldom to see soprani transform themselves into basses.

It is said that *Lablache*, in his youth, was accustomed to sing in church on Sundays. But during an epidemic, many children were unable to attend the singing, and *Lablache*, who possessed a fine soprano voice, was asked to sing the alto; this required more than some straining on his part. In the afternoon, he was astonished to find that he was incapable of delivering a good tone, and his belief was that his voice was spoiled for some time; but to his great surprise, the next day, when he tried to sing again, he found that his voice had been changed into a bass, which has since then been so greatly admired.

The breaking takes place more easily in girls, as the development of the larynx is very slight in length, and is only accentuated in breadth; the voice goes down of one or two tones only. This transformation occurs between the age of from eight to fifteen, according to the climates. In boys, it appears at about the age of thirteen, but it can last exceptionally until the age of nineteen or twenty.

In 1908, *Scheier* mentioned the case of a young girl of sixteen who has been regularly menstruated until she was fifteen. Her menses stopped then, and her voice, from a soprano, became a bass. The vocal cords were longer and more voluminous than those of many girls of the same age; the larynx had increased in volume and the Adam's apple formed a prominence. The voice extended from the bottom *Do* to the high *La*, thus covering nearly four octaves, and could deliver most perfect head notes.

Though the breaking takes generally place all at once, there are however cases where just before puberty, the voice becomes hoarse and the larynx painful. The same phenomena can occur two, three, even four times, then the real breaking takes place, in conjunction with the development of the other organs.

Sometimes the breaking is late. It happens that an individual who, at the term of puberty has got a tenor voice for instance, experiences again laryngeal disorders, and finds that he has lost high notes, won a few deep ones instead, and from a tenor become a barytone : this is the first breaking. Later, in the same individual, a second breaking can take place and change the barytone into a bass. The larynx has further increased.

The following case happens also sometimes : the congestive work of the breaking, having slightly passed the limits which had to be reached, can retrograde in an imperceptible way; this is the explanation of the phenomenon by which a tenor who had acquired the tessiture of a bass can become permanently a barytone. But this bass tessiture can also be in reality a voice which has been displaced.

If these singers have the tessiture of a bass, they have not in the least the timbre characteristic of that voice; such is the case for our colleague Dr. *Bergeron*, who has made the breaking of the voice the subject of his inaugural thesis. His professor at the Conservatoire of Music of Lyon, told him that he had the voice of a large bass; he was at that time able to sing from *Mi*^{2} up to *Mi*^{4}. At Paris, the following year, his voice had become the voice of a barytone, ranging from *Sol*^{2} up to *Fa*^{4}. His new singing-master asserted that he had in fact the voice of a baryone, but that it had been displaced.

In women, at the time of the menses, it happens frequently that for a day or two, the voice does not come out properly or goes up with difficulty; it is for that reason that some artists stipulate in their contract, that they will not appear in public during that period.

At the critical period the voice has a tendency to go down and to take a deeper timbre. These changes in the voice, at the time of the cessation of the menses, do not occur all at once, and are sometimes long in taking place, specially if the voice is continually practised.

With old age, the voice loses its intensity, owing to the diminution in the force of the pulmonary expiration, caused by the disappearance of the elasticity of the vesicles of the lung, and by the relaxation of the muscles of the thorax. The laryngeal muscles lose also their elasticity; the articulations become more or less ankylosed; for all these reasons the range of the voice diminishes, the high notes disappearing. A similar alteration is observed for the pharynx and the mouth.

It happens sometimes that the breaking does not take place at all in certain cases, when the development of the genital parts is impeded; these organs and the larynx are developing parallelly.

In individuals, when the sexual organs are either missing or of small proportions, or even in those where the development only takes place late, the voice resembles more the voice of a woman than of a man.

Eunuchs. — When the castration is performed before puberty, the eunuch keeps the shrill voice of his childhood, but with a timbre approaching the one of a soprano.

At the time when in certain countries, like Italy, no women were allowed to go on the stage, their parts were held by the « musici ».

Struck by the melody of the voice of the eunuchs [1], the Roman church kept them for a long time in her service to sing the glory of

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[1] Let us name amongst the most celebrated: *Beldassare Ferri, de Pérouse. Carlo Broschi*, surnamed *Farinelli, Gastano Maiorana*, surnamed *Carafelli* who underwent the castration on the advices of his first teacher *Caffaro*, and *Girolamo Crescentini* whom *Napoleon* wanted to bring back to Paris.

God, and thus contributed in perpetuating this infamous fabrication (*Kock*). The musico had the voice of a woman with all its melody, the pitch of a child's voice and a powerful range owing to the enlargement of the resonators. As women were not allowed to sing in church either, and as a link was needed between the children's and the adults' voices so different in timbre, one had recourse to the castrati, for the purpose of completing the perfection of the celebrated choir of the Sixtine Chapel [1].

In 1870, the Sixtine Chapel was composed of about thirty men; the soprano was held by six eunuchs and by falsetto voices. The soprani, according to a remark of *Franz Witt* have their best notes between *Fa*^{4} (870 d. vibr.) and *Do*^{5} (1740 d. vibr.) which cannot be reached by a falsetto voice. The best soprano was *Mustapha*, an eunuch aged 53, whose voice went up to *Mi*^{5} (1350 d. vibr.).

These choirs of the Sixtine Chapel, which have been so famous of old, have entirely lost their reputation. Since the death of *Baini*, who was Master of Chapel of the Vatican from *Gregoire XIII* to *Pie IX*, the choirs that have been left in the hands of mediocrities have declined more and more : one made them the reproach of not singing in tune [2].

When the castration is performed after puberty, it has not bearing upon the voice. Catholic priests and monks, like *Origen* and his sectators, have been known, led by false ideas, in so much as their chastity was no more voluntary after their castration, to have this operation practised on them, so as not to fall into temptation; but as they had reached middle age, they were only able to sing as before : their voice was in no way altered.

In the Russian sect of the *Skoptzy*, founded in 1757 by *Iwanow*, the adept, operated young, keeps the voice of a child on account of the larynx being stopped in its development; but the voice becomes louder, owing to the widening of the thoracic, buccal and nasal cavities. If the operation is performed only after puberty, the voice keeps all its natural purity, however it can never be compared to the voice of a young castrato.

The woman whose ovaries have been taken away before the time of puberty, for the purpose either of stopping the spring of

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1 In the XVIIIth century, the pope Clement XIV had succeeded in composing the choir of his chapel of the most renowned soprani. An Italian Abbé, *Joseph Parini*, amused himself by publishing in the *Gazette of Milan* that the pope had ordered that in future, no singer having undergone castration would be admitted either in he churches, or the theatres of the Roman States. He furthermore engaged all the Christian princes to promulgate a similar interdiction in their own states. France especially congratulated him for having taken this initiative. But the pope was not long in contradicting « this stupid rumour, this infamous calumny ». (*Paulin*, 1845. Cur. litt., p. 288.)

2 I wish to add that these choirs have been singing lately in Paris, where their excellent performance has however still been much admired.

desires (?) or of fighting an illness, undergoes a metamorphosis which is just the reverse of the eunuch's : the pileous system takes a greater development, the voice loses its softness, and morally she acquires the roughness which characterizes the « virago ».

To obtain by castration the proposed object, it is obvious that the operation must be practiced on both organs at the same time, and be complete on each of them. As the monorchids, like *Sylla* the Dictator, the cryptorchids, the women with one ovary, have nothing abnormal in the voice.

When the ovariotomy is complete, that is when both ovaries have been taken away in adult women, the voice does not seem to be altered. If Dr. *Moure* has seen two soprani become contralti, the Drs. *Poyet* and *Ruault* have never observed any similar cases, on the contrary! I agree with the latter, for I have been able to observe at least ten instances in women, who had undergone this double operation, and I have never noticed the slightest transformation in their voice; these arists have continued to hold on the stage the parts they sang previously, and nothing was changed in the timbre or tessiture of their voice, amongst them is one of our best-known singers:

The excesses in incontinence have a considerable influence on the vocal apparatus.

Hippocrates had observed that the prematureness, or the frequency of the sexual act worked on the singers. It is a well-known fact that the bass-voices keep all the deepness of their bass only by being continent. It is for that reason that the Romans infibulated their singers. This operation consisted in passing a ring either in the skin of the prepuce of the man, and in the small or the big lips of the woman.

CHAPTER XVI

THE STUDY OF SINGING.

When should the study of singing be commenced? — The mechanical study of music can begin at about the age of seven, but the education of ear, respiration and articulation must also be considered.

The training of the ear is a matter of importance : *Schumann*, addressing a young pupil writes : « Take the habit early to try and recognize the major, the minor, the different tones... When you sing, do not trouble to know who hears you. Always sing as if a maestro was listening to you. » One must therefore make the pupil name the note he utters. He acquires thus vocal justness.

One does not give enough attention to the development of the hearing in singers. How often have we heard artists, who had already a long career behind them, sing at least a quarter of a tone below the tune, and be absolutely satisfied with the justness of their voice! How many amongst them are quite incapable of recognizing the tremolo, if it does not take the proportion of a real bleating!

It is painful to have to admit the truth of what a critic wrote recently, concerning the competitive examinations for song and lyric declamation of the Paris Conservatoire : « Each time that in an examination a voice is heard which neither trembles nor breaks down, the praises of the teacher are loudly sung by everybody. Really one is too easily satisfied if one admires exceptions which ought to be the rule.[1] »

A correct respiration is an essential condition for singing well, and the right way of breathing is to use the complete, and not the diaphragmatic, the lower costal or the upper costal respirations, as

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[1] How is it that the members of the board of examination, on which is also our critic, should give rewards, and even prizes, to pupils for whom tremolo is the ordinary state of voice? It is really the way of encouraging the « *art* » of quavering, and trying to prevent any progress, as regards the improvement of the classes of the Conservatoire.

each of these partial respirations requires the working of muscles which offer opposition to those which ought to be set into action; in other terms, if one wishes to use exclusively the costo-thoracic respiration, the midriff must be kept motionless, hence an effort has to be made so as to obtain that result, and every contrivance, which necessitates an effort in singing, determines rapidly vocal disorders.

The child will have to practise respiratory exercises, as afore indicated. Besides learning how to hold his breath, and how to deliver the notes in varying the intensity of the tone, he will acquire thereby a muscular flexibility, the benefit of which will soon appear to him.

He will be made to sing on all the vowels and on the syllables, care being taken that the organs are placed in the correct positions, so that the tone should be produced according to the principles aforementioned. And as the question of holding the tone is generally neglected, as I have been able to observe many times, by means of graphs taken from singers, it is advisable that the child should be made to practise exercises on one note, then on two adjoining notes, afterwards on thirds, etc.

During the time of the breaking, all vocal training will be avoided. The boys will have to wait until the breaking is accomplished to take singing lessons. At that moment their voice will have acquired strength, timbre and greater energy. However it is only at the age of 27 or 30, that the masculine voice reaches its entire development. Girls can begin to study singing much earlier, as the breaking is almost imperceptible in their case. But if it happened that any disorders should appear in the voice, at that period, the lessons would have to be ceased. Likewise, at the time of the menses, it is better to rest for a few days.

When *Donzelli*'s voice began to break, one of his fellow-scholars, *Donzetti*, elder brother of the maestro, who was in the same case, continued to practise his singing, and very soon lost his voice. But *Donzelli*, who had followed the advice of his master, and had ceased to sing during the whole period of breaking, acquired in the contrary an excellent organ.

If one has avoided to sing during the breaking, a few high notes can be gained afterwards; but it is necessary for that to practise gradually and without effort. *Bennati* relates that from early childhood, his chief care was the study of singing; his soprano voice had a great range. When he was fourteen, his voice began to break, and his master interrupted his lessons. After many months, the latter remarked that *Bennati*'s voice had gone down a whole octave, and could at the same time render some of its former tones.

He advised him then to sing the tones in a certain order and without straining himself, telling him that these same tones would furnish him later this second register, of which the tones would gradually join those of the first register, and that great advantage would be thus secured for the future. It is to this training that *Benatti* owed the compass of his voice which covered three octaves.

When the breaking has entirely taken place, the pupil will be able to take up the study of singing, but he must not try to deliver the extreme notes either shrill or deep.

« If one begins by training the voice specially in the middle, as the production of tones in this part of the vocal scale scarcely requires any effort, one contrives to the progressive development of the skill and of the muscular strength. But if one tries from the start to push the voice towards the thin or the thick, one only succeeds in tiring the laryngeal muscles unadvisedly, hence in irritating the vocal membrane, and in compromising the clearness and the sonority of the voice. »

Until the pupil has secured the « mezza di voce », he must not try to increase the range of his voice. He must learn first to pitch and to conduct the tones, that means : to vary the force of the sound, amplifying and lessening it without altering the height of he tone; and when he is at last in full possession of his middle range, he can then try to develop his low and upper tones without fearing to strain his voice. I will not go further in that matter which concerns the singing-master.

How to hold the tone. — To hold the tone, that is to leave to the note its pitch and intensity during the whole length of its production, is one of the essential conditions in singing, unfortunately one which is seldom fulfilled nowadays! The singer does not know any longer, how to give the note its proper number of vibrations. For instance, if one is singing a normal *la*, *la*^{3} (435 periods) the note, instead of keeping this constant number of vibrations, may successively pass to 440, 445, 453 periods (453 periods = *la* ^{3}); thus being in this case raised from a semitone. But generally the contrary takes place, the number of periods decreases to 430, 420, 415, 407, and the note reaches the *Sol* ^{3} (407 per.), thus going down a semitone. The note is no longer in tune.

These variations of periods are due to the irregularity of the expired air. If the intensity of the breath is too strong, it will affect the pitch of the note, by increasing the number of periods, thus raising the tone of the note. Contrariwise if it is too weak, it will provoke a diminution in the number of vibrations, thus lowering the pitch of the sound.

Therefore the vibrations of the note as to the pitch are bound

to the regularity of the expiration, in other words, the justness of the tone depends directly upon a good respiration.

It is with the purpose of getting the pupils accustomed to sending out their breath, with regularity whilst singing, that the advice has been given them to put before their mouth a lighted match; the flame of which must keep in the same position, from the begining to the end of the utterance of the tone. One can vary this experiment by making use of a little tissue paper flag, fastened to the extremity of a rigid stem. As long as the uttered note lasts, the flag must keep motionless in the bent position given to it by the breath, from the moment it came out of the mouth.

Besides it is easy to make sure, with Verdin's spirometer, that the breath retains well all its regularity (Fig. 8), by observing the movement of the needle on the dial. The needle must turn regularly, without proceeding by jumps.

I cannot help advising the pupils to practise slow blowing exercices, so as to acquire a satisfactory supply of expired air.

When one has become quite master of one's breath, one can begin the exercises for pitching the voice, by delivering the series of vowels on a note in middle voice, giving it alternately the value of a crochet, of a minim and lastly of a semibreve. The scale will be climbed in this manner, up and down by semitones, but one must be careful not to go till the limit of the voice is reached.

When this exercise on the vowels will be found of easy execution, it will be repeated on the syllables *pa-pe-pi, ta-te-ti, ba-be-bi, da-de-di.* It will be observed that it is better to start practising on the syllabes, as it has the advantage of favoring the normal attack of the tone.

Later on, the pupil will practise with parts of sentences, singing alternately on the different notes of the scale. Thus he will sing, on *Do* for instance, a verse such as the following one :

On *Do* : En fermant un peu les yeux
Je vous vois déjà vieux
And on *Ré* :

He will endeavour to hold the breath on longer verses, being careful to take a fresh respiration at the end of each verse only. By the practice of these various exercices, homgeneousness, justeness and purity of the tone are acquired, likewise the knowledge of how to hold the notes.

Later on, the pupil will undertake the study of crescendo and decrescendo, by gradually increasing or decreasing the pressure of the sound. He will be able to produce « *spinned notes* ». Afterwards will follow exercises on an interval, on thirds, on fourths. Then the pupil will vocalize. One can find, in any amount of well known elementary treatises, the different exercises written for the purpose

of giving to the voice agility, and all qualities which must necessarily be acquired so as to become a good singer.

Time to be devoted to study. — The practice of the voice must not last until fatigue occurs. It is difficult to fix any limit to the vocal exercises, as the constitution and the resistance of the organ vary with the individuals. Some people can speak or sing during hours without feeling tired (these cases are rare), whilst the greater majority are incapable of such exertion.

In the begining, one must practise during five or six minutes, then rest, and proceed in this manner for half-an-hour; later, exercises will be sung for a quarter of an hour, then for an hour at a time, with a few minutes rest every quarter.

One must avoid singing in small rooms, which are fatal as far as the reach of the voice is concerned. One must not sing before digestion has taken place, but wait until about two hours and a half after the meals. One must be aware of either too hot and too cold premises, and be careful not to walk much, nor too quickly immediately before having a lesson. Also when an artist gives a performance, he must not practise too long that day.

We encourage the pupil to follow the counsels of Mrs. *Cinti-Damoureau* : « one must not be satisfied just to render notes, and to execute more or less difficult passages, but endeavour to give them tone to animate and accentuate them, and for that purpose the artist must be penetrated with the words, the signification of the piece, or the scene which is being sung. The physionomy even must reveal, so to say, both the subject and the character. It is necessary to add that the articulation and the pronunciation must be irreprochable. » These recommendations are of the province of the teacher; however I will add a few counsels to the artist on the way of holding himself.

He must hold himself straight, with shoulders thrown back, head high, arms drawn back, without touching the chest. The chin must not be pressed upon the neck, as this could hinder the movements of the larynx and of the mouth.

The voice must not be directed downwards, but towards the spectators upon whom the sound must be projected. It is not necessary to raise the brows inordinately while attacking the high notes, or to shut the eyes as if one was going to faint away out of sheer delight in hearing one's own voice. One must not bend the body forward, nor indulge in vibratory movements of the hips, nor stamp with the foot at the end of a phrase or when delivering a high note. Neither is it necessary to move in time, or to beat it with the head or the feet. No good is done by agitating either lower jaw or tongue, as similar movements would encourage tremolo; lastly, it must be

remembered that faces and contortions of the mouth do not help to deliver notes, not even high ones.

Bennati relates that each time the Countess M. gave *Ut*[5], she carried her mouth to the left. In examining her mouth, one day during the production of the high tone, he found that the kind of rill which is formed by the tongue each time that head tones are uttered, instead of filling the middle of the tongue, was displaced to one side. I have myself known an artist, from the Paris Opera, who delighted the spectators by the curious positions he used to give his mouth and tongue.

It is for the purpose « of artificially placing the upper-glottic resonators, in accordance with the vocal note », that one must have recourse to sleights and tricks, and thus modify the play of the cheeks, of the tongue and of the lips [1]. This is the opinion expressed by certain professors!

If from the beginning of his lessons, the pupil were better advised, he would not catch such deplorable habits!

Bennati, who realized all the importance of the play of the organs, obliged his pupils from the age of seven to take lessons in mimic art; they were made by him to open their mouth, and to give their resonators the form necessary for such and such a tone, then — and then only — could they sing the note. In that manner they got perfect control over their muscles. Experience has shown this clever artist that the singers, who have not practised these preliminary exercises, have many difficulties to overcome : for instance, *Crivelli,* an excellent barytone, having only begun to sing when he was thirty, was incapable, in spite of all his efforts, to produce a head note.

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[1] *Quintilius,* of old, had said not to twist the lips, but to avoid opening the mouth inordinately and also not to turn the face up, nor to hold the eyes downcast « I have seen people who, with each peal of the voice, lifted the brow, or others who frowned ». (Complete works V, I, p. 108-109.)

CHAPTER XVII.

ILL-USE AND OVERWORK OF THE VOICE.

The bad working of the vocal apparatus, or more accurately the antiphysiological use of its component parts, or else the abuse of vocal work are the causes of most of the accidents which occur in the course of the singer's career.

They are brought by : :

a defective breathing,
an erroneous classing of the voices,
a bad voice break,
a wrong position of the organs, with defective attack,
an insufficiency of the studies,
and the overwork of the voice.

Defective breathing. — To breath well, one must take a slow inspiration through the nose, keep the air a moment in the lung and expire somewhat more rapidly. Afterwards, one exercises oneself in prolonging the expiration by letting the breath go slowly out, so as to obtain a calm and deep respiration, which allows the accumulation in the lungs of the great quantity of air necessary to the singer. That is the way of making the chest work according to each of its diameters, and of effecting thus a complete respiration.

Breathing has a considerable influence on the vocal condition. The firmness, the intensity, the resonance of the voice, the holding of the tone depend on the respiration, and it is often in an alteration of the respiratory mechanism that the vocal lesions take their origin, as is easily proved by the graphics of the respiration, which point out clearly the dissociation of the movements of the thoracic cage. It is therefore necessary to react against « the confusion which rules in master in that quarter », as *Biaggi* expresses himself, and to make use exclusively of the complete respiration.

If women use generally the clavicular breathing, characterized by the raising of the upper part of the chest, and the depression of the stomach hollow, the fault rests with the wearing of stays, which compress the waist, prevent the expansion of the thorax, and therefore demand this respiratory mode which provokes rapidly breath lessness and congestion of the head, with projection of the neck and tightening of the lateral part of the throat, and which determines thus the formation of granulations.

Fashion has partly modified this mode of breathing.

Certain singers inflate the abdomen in the inspiration, without hardly moving the lower ribs. The stomach protrudes so much the more as the movement of the midriff is more pronounced. This type of breathing has the disadvantage of submitting the organs, held in the abdomen, to an excessive pressure during the inspiration, and to demand from the muscles of the abdominal wall an energetic contraction, at the time of the expiration.

The costal, or costo-lateral breathing is characterized by the widening of the lower part of the thorax, and the flattening of all the anterior abdominal region situated below the under-costal line. According to Dr. *Joal* many artists have recourse to it. But it is obvious that to obtain this sinking of the abdomen, it is necessary to recur to a contraction of the midriff, which keeps this muscle from accomplishing the complete movement executed in the inspiration of the abdominal type. How great must be the preoccupation of an artist, who has to think of preventing his midriff from doing its work and, at the same time, of ordering the raising muscles of his thorax to lift the lower ribs! And what excessive work is thereby required from the muscles of the chest and from the midriff!

It is easy to realize the bearing which such a way of breathing (that prevents the free play of the organs) can have upon the voice. Thus the breath is deprived from a part of its power and intensity, and the way to tremolo is prepared.

How often have I told singers who made use of these respiratory modes, to execute the complete respiration! If they followed the advice, the progress realized was soon very noticeable. For instance, a singer, whose respiratory capacity was of 3 litres, increases his air volume of one litre and a half. To give an example, I will cite the case of *Saleza* who, in 1895, had a pulmonary capacity of 4 litres, and who, the following year, obtained 5 litres, thanks to the practice of pulmonary gymnastics.

The pneumograph has been the means of confirming the ordinary use which many singers make of the complete respiration, when their nasal chambers are normal; this is an essential condition of good breathing.

Generally the results are not so striking in women, who nearly

always wear clothes which press on the waist and the stomach. Nevertheless I have been able to observe increases of 1 litre or even 2 litres, as in the case of Mrs. A., a social singer.

To breathe at the right moment whilst singing, is an art mastered by the consummate artist who knows how to take a fresh respiration on a musical rest. However in quick movements, it is sometimes difficult to take a nasal inspiration, one inhales then the air exceptionaly through the mouth.

The correct method which consists in taking the breath at the time of the musical rest is easy to verify, thanks to the registration of the thoracic and abdominal movements, by means of the apparatus which are reproduced in Fig. 10, 11 and 12. A concordance must exist between both.

Nowadays modern music is seldom well written for the voice. The composer hardly worries about the artist. Consequently one is too often called to observe the fact that the thoracic and abdominal curves no longer correspond to the musical rests, hence the necessity for the singer to lengthen or to shorten his respiratory rhythm; thereby the obligation for him to possess a great respiratory skill. If such is not the case, the artist will very quickly lose all his vocal ability.

An artist, who does not possess an ample respiration, or who does not know how to spare his — or her — breath, is obliged to breathe frequently, hence a diminution in the duration of the musical phrases, a loss of amplitude and intensity in the tone, and a fatigue of the muscles which no more respond to the will and no longer have the necessary vigour and suppleness; this results in tremolo and in approximation of the vocal cords which is insufficient to produce the tone, with congestion and chronic inflammation of the organ, causing the voice to be covered and hoarse.

Besides these desastrous effects of bad breathing, there are others determined by the weak attack on the breath. This way of attacking demands a great quantity of air, a part of which only is used for the production of tone, the other part running out between the vocal cords which are not close enough together. If the breathing is already defective, it is not surprising that disorders of the voice should soon break out.

In addition to the results which are derived from bad teaching, can be mentioned those which are engendered by the nonchalance of the pupil who does not impart to his muscles the necessary energy, or by the bad condition of his — or her — respiratory organ (obstruction of the aerial ducts, by reason of the inflation of the turbinated bones, deviation or thickening of the nasal septum, adenoids, etc...), or again by a lesion of the neighbouring organs impeding the working of the midriff (dilatation of the stomach,

excess of fat, or alteration of the cardiac apparatus), without speaking of stage-fright, or « trac », and above all, the excessive compression wrought on the body by clothes, belts or corsets.

Stays. — The wearing of stays alters the way of breathing in women : the respiration becomes clavicular.

Researches made on races which have never made use of stays have proved that the women's breathing does not differ from the men's. By measuring the respiration of certain tribes, like the Cherokees and the Chukassaws, where some women wear stays, one has found that the latter had a clavicular breathing, whilst the rest of the tribe had a different respiration.

The corset exercises a constringent action upon the lower part of the women's thorax, by squeezing towards each other the five or six last ribs (Fig. 152). Thus the aspect of the thoracic cage is modified; it loses its conic shape (Fig. 151), as its base is perceptibly rendered narrower by the wearing of this cuirass. The normal position of the viscera (Fig. 153) is altered (Fig. 154); the lungs, *Pd* and *Pg*, and the heart, *C*, are driven back inside the upper part of the thorax; the stomach, *E*, the spleen and the liver, *F*, are pushed down and the movements of the midriff, *D*,

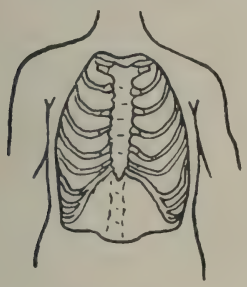

Figure 151.
Normal thoracic cage.

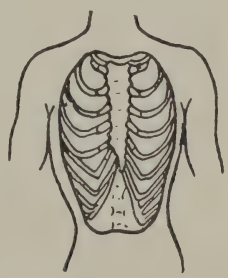

Figure 152.
Thoracic cage deformed by the wearing of stays.

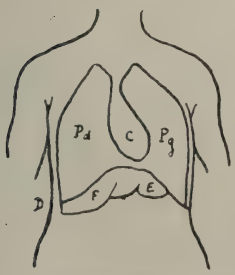

Figure 153.
Normal position of the viscera.

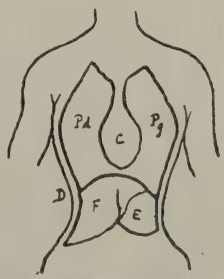

Figure 154.
Displacing of the viscera by stays.

being impeded, this muscle acts but feebly upon the breathing [1], hence a modification in the exchanges of the lung, resulting in the diminution of the oxygen, an incomplete elimination of the carburets of hydrogen which, being no longer burnt, provoke the development of stoutness, and also in disorders of the circulation marked by the congestion of head, throat and larynx, sometimes even by fits and syncopes.

Furthermore, the stays give an impression of uncomfortness, and also a sensation of fulness on the level of the epigastrium (stomach hollow), for the surfeit at the time of digestion can only take place by the displacing of the subjacent intestinal mass, which is driven back towards the under umbilical parts, which alone have kept their mobility. Let us add that the lowering of the intestine entails also the lowering of the liver and the right kidney principally (enteroptosis or sliding kidney).

By reason of the forced working if this sub-umbilical part of the abdomen, which has to resist to the pressure of the totality of the organs contained in the abdomen, a distention of the lower abdominal wall is produced after a time, carrying consequences which bear on the intestine (abnormal progress of the gases and of the excrements, ordinary constipation, etc.), and also on the genital organs (lowering and displacing of the womb and disorders in the menstruation).

On the other hand, if the stays are worn on the sub-umbilical, or hypogastric part, the same phenomena, which have just been described, are reproduced, but in the upper-umbilical region which relaxes and forms what many women call in France « la boule », at the same time as the base of the chest broadens.

The conclusion which can be drawn from all the foregoing considerations, is that the stays must be flexible and extensible, take a prop on the spine and fit exactly the abdomen, leaving the false ribs free, and covering the front part of the body from the lower extremity of the breast-bone to the pubis. Furthermore, to prevent the organs from being displaced, it is advisable to put on the stays while being in bed.

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[1] The vital capacity of the woman who wears stays, is by 375 cc. smaller than the one of a woman who does note make use of this article of dress (*Kianowski*). The respiratory excursion of the thorax is considerably diminished : differences of several centimetres are observed. The detrimental consequences of the wearing of stays have been the object of the attention of several governments. In 1902, the Minister of Public Instruction, in Roumania, prohibited the girls in the schools from wearing stays, because of the permanent obstacle they constitute for the normal development of the organs.

In 1904, a similar interdiction was made in the schools of Bulgaria.

In Germany, stays are forbidden in the schools during the drilling lessons; and in Russia, the girls in the grammar schools are ordered « to leave off at the entrance the cuirass they wear under the name of stays ».

If the outer compression of the trunk (belts, stays) increases the length of the inspiration, on the other side it lessens the amplitude and provokes a greater frequency of the respiratory movements, consequently it facilitates the production of all the disorders consecutive of a defective breathing.

The best way of avoiding these accidents is to have recourse to respiratory gymnastics, and to practise the exercises which I have explained above (p. 31) and in my book on *Respiration and pulmonary gymnastics* [1].

Erroneous classing of the voice. — Nearly always the initial cause thereof is due to the professor who, taking only notice of the tessiture and neglecting the timbre, places in the same category all the scholars who possess the notes included between the extreme limits of this tessiture. According to him, a barytone who could deliver *La*^{3} or *Si*b^3 would be a tenor.

But if a preliminary examination of the vocal organ had been made, it would probably have been observed that the shape of the larynx, and the dimensions of the upper-glottic cavities, did not answer to the qualities of which I have spoken previously, in connection with the tessiture.

In any case, the registration of the voice would have shown that the extreme notes were bad as regards the timbre and the tessiture, and furthermore that the note was not held regularly. Thus the sight would have corrected the ear, which does not always perceive the variations of pitch when they are not very marked. In short, the examination of the graph would have made it possible to prevent a fatal vocal catastrophe.

But the professor continues to err, making even the pupil work on his bad notes, for the purpose of bestowing them with a power they will never get; and the voice loses its timbre. All the tones produced seem to be delivered on *a*, owing to the guttural effort the pupil has to make to bring out only a panting voice. The pupil should stop singing for a lapse of time more or less long, according to the state of exhaustion of his organ, and see what happens when after weeks he tries only to utter a few tones, mouth shut, principally on the nasal vowels : *an, on, in,* which require for their production the relaxation of the soft palate and consequently a feeble energy of the air current.

How many singing-masters act thus to try and develop the compass of the voice, making it pass its natural limits, without realizing the fatigue it imparts to the pupil and without knowing that the high notes require a greater intensity of tone!

It is not rare either to come across professors who, without taking any heed of timbre or tessiture, wish their pupils to sing

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[1] Paris, 1912. Vieu ed.

all the notes, from the contralto up to the soprano, or from the bass to the tenor, reserving themselves to make a choice later regarding the quality of the voice. These teachers, who seem to assimilate the vocal cords to an elastic band, contend that one must pull on them so as to increase the pitch of the tone. But the vocal organs cannot be treated in that way without inconvenience, and before long it is made too clear that the extreme notes have disappeared, and that notes of the middle alone have been sometimes preserved, as may be ascertained by the reading of the vocal graph (Fig. 155).

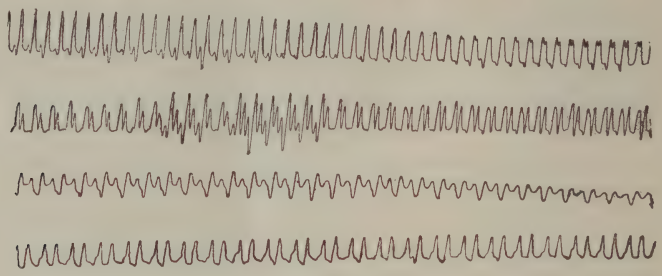

Figure 155.

A sung on different notes by a girl pupil whose tessiture one has tried to lengthen, both in the deep and the high notes.

*La*³ (435 periods) shows only 420 and 407 periods, viz. the note has gone down by a semitone.

*Ut*⁴ (522 periods) furnishes 543.75 per. corresponding to *Ut*♯⁴.

*Mi*⁴ (652.5) gives 696 per., = *Fa*⁴ and 660 per. = to *Mi*⁴.

*Sol*⁴ (783) has even 840 per., thus reaching nearly *La*⁴ (870).

In this graph, one can see that deep and shrill notes are taken above or below the normal pitch; the difference is sometimes as great as a tone, or a tone and a half. As for the way the note is held, it is irregular and goes down easily to the extent of 40 to 50 vibrations, or even more. The timbre and the intensity, according to the same graph, présent irregularities which betoken the tremolo and the blank voice.

These cases must probably not be rare, seeing the number of professors who redress the wrongly pitched voices.

If the singing-master had some notions of the anatomy and physiology of the vocal organ, (I am not speaking of « the mysterious physiology, as if it were scattered, which the artist, with his refined sense of divination, can more surely pervade » according to the terms of a professor at the Conservatoire, physiology which the singing-master, it seems, is alone to know), if then, he proceeded, as I have said, by making the pupil practise on the note of the middle, so as to judge of the real direction of the voice, many such accidents would be avoided.

There is still a category of singing-masters who are eager to change the tessiture of their pupils. I have often met samples of

them. *Bertrand* writes : « Certain professor is never satisfied with the voice which is brought to him, and undertakes to give a new one, after having cleared away the first. » I may add that I consider the pupil lucky if, after the latter operation, some particles are left to him, and if the voice is not entirely lost!

Let the word of *Morell-Mackenzie* be borne in mind : « It is as impossible to change a barytone into a tenor, as to make a grasshopper of a black bird. »

There are a few examples of ill classed voices: *Pisaroni, Grunaldi, Quiney* and *Eugénie Garcia* had sung the soprani before attacking the contralti. *Jenny Lind,* from a shrill soprano, has become a mezzo.

Beraldi, from a tenor has passed to deep bass; *Galli,* after having been a tenor has become a bass.

This is easily explained, and unhappily occurs frequently! One has tried to extend a voice, the notes of which, in the lower part of the tessiture, had perhaps not yet the amplitude which they would have acquired by study; but the notes of the high register could only come out by means of a certain amount of effort, fact which the artist realized in the long run.

The contrary phenomenon has sometimes also taken place in tenors. For instance there are the cases of *Elleviou* and *Mierzinski.* The former was rather a mediocre bass and became a delightful tenor, but the latter, whom I knew closely, was unable to keep the new part he had thought fit to take, and he soon lost a voice whose tessiture was too high for his organ.

The case may be different for other tenors who have sung at first the parts of barytone, like *Chollet, Mario, Sims Reeves, Nicolini, Lhérie, J. de Reszke, Lafarge.* To this list can be added *Alvarez,* who had written himself down as a barytone for the transmission examinations of the Conservatoire, for which besides he was never qualified!

But all the barytones changed in tenors I have heard on the stage have perhaps not made quite such a long career as if they had simply staid barytones. And it is avered that for some of them, it has been necessary to take out of the works they sang passages which were too high for them as : « Ah! lève-toi, soleil » in *Romeo,* or to lower the tessiture of certain pieces. In *Faust,* a tenor was obliged to alter the music which was at tunes written too high for his organ.

In these cases can the artists be considered as real tenors? As I have had the opportunity of examining several, I am convinced that these high barytones were not truly tenors. If their larynx answered the conditions previously expounded, their upper-glottic cavities were not shaped to fit the requirements of tenor parts; they were wider than in tenors generally.

To change of employ or to try and extend the tessiture are mistakes which have frequently to be paid by an abreviation of career. Evidently it is a question of money which lies at the bottom of such modifications of employ. One forgets the fable of the ox and the frog : the light tenor wishes to become a strong tenor; the half-character barytone is ambitious to be a Grand Opera barytone; and the mezzo-soprano has no other desire than to become a soprano! What good comes out of these changes as a rule?

One of these high barytones had a voice which extended to *Si*. Following the advice of an improvised professor who had the great speciality of lengthening the voices, and therefore was at a time quite the fashion, this artist, who sang the tenor parts, decided to take a few lessons with this teacher who had promised to give him easily *Ut*. The result was unfortunate : the pupil lost his *Si* and retired just in time to save the rest of his voice. This is an instance of one of these barytones who have tried to exceed their means, and have only succeeded in shortening their career. They have not had the sage prudence of *Faure* who did not hesitate to refuse certain parts which were too high for his voice, thus reminding us that all the barytones cannot sing the parts written by *Rossini* and *Verdi*. One, for instance, who sings *Traviata* or *Rigoletto* will not be able to take up *Nevers* or *William Tell;* and if others possess a deep register which allows them to play certain bass parts, at the same time as an easy high register which gives them the means of approaching parts accessible to barytones, it does not follow that a bass will be able to fill the parts of *Delmas*, from the Paris Opera, Likewise all the tenors who sing *Faust* (in which already some of them are obliged to make a transposition) have not the possibility of playing without inconvenience *William Tell*, *Robert*, or *La Juive*.

The case is the same for soprani who, in the space of a few days, sing successively in *Charles VI*, The *Favorite*, The *Prophet* and *La Juive*, thus compelled by unreasonableness of certain country directors to take parts which exceed their powers. Everybody cannot renew the feat of *Merly*, a lyric bass who, after having taken the part of *Marcel* in The *Huguenots*, sang soon after the part of the tenor in The *Vestale*.

Certain composers, like *Haendel* and *Rossini*, have always taken into consideration the powers of the larynx and have written for the voices; but others unhappily have not had the same care; they seem to ignore the tessitures and to believe that a human throat can deliver all the notes, like a piano.

It had already been stated by *Ch. Delprat* that « the fatal system of transforming the voices, and of giving them what they do not possess, is a daily practice, even in the big academies of music ».

The fascinating wish to become the rare bird, as the tenor is considered to be, will still go on spoiling the career of numerous barytones : the list of these unwise singers is certainly not yet closed!

Defective voice break. — I have already said that the break between the chest and the head registers occurs generally at between *Mi*^{3} and *Fa*^{3}, or at between *Fa*^{3} and *Sol*^{3} in the soprani, and at between *Mi*^{3} and *Fa*^{3} in contralti and men.

It is not rare to hear tenors utter *Sol*^{3}, in chest voice, and even *Ut*^{4}, like *Duprez, Tamagno,* or still *Ut* ♯ ^{4} like *Tamberlick,* a fact which makes the whole audience break out in a thunder of applause, and leaves it too astonished to take much heed a few moments later to the tenor's « couac ».

Certain contralti also pride themselves in reaching *Sol*^{3} and *La*^{3}, and in going even higher in chest voice, thereby running the risk of ruining their voice. It is easy to see by examination, what violent muscular contractions have to be made so that these should be produced.

I have had the occasion of observing many such cases, as for instance in two artists, one of whom made use of the chest voice from *La*^{2} up to *Mi*^{4}, and the other from *Si*^{2} to *Ré*^{4}, viz. upon a range of more than one octave (Fig. 156).

A similar proceeding necessitates a supplement of work on the part of the small muscle crico-thyroideus which, being immoderately contracted, gives way under the effort; the result is that the following high note has neither the purity nor the justness required, owing to the excessive fatigue of the muscle.

What happens here is the same as what occurs when a too heavy weight is held at arm's length : at a certain time one is obliged to let the object drop, the muscular effort being exhausted.

How many artists have been forced to abandon the stage for having committed similar excentricities which had determined the loss of the middle voice, the fatigue of the voice (*hole in the voice,*

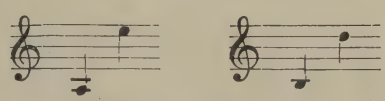

Figure 156.
Abuse of chest voice.

forced voice) and the tremolo caused by the muscular exhaustion!

« The number of women's voices broken by this cruel misuse is considerable » (*Battaille*).

« One of our most sympathetic woman singers, who has so brilliantly held the leading part in one of our principal lyric theatres,

intoxicated by the success she was sure of winning through the use she made of her chest voice, has greatly helped to shorten her theatrical career by being unable to restrain herself from carrying it above its natural limits » (*Faure*).

Recently, there has been another example of the same fact given by an artist, whose voice offered no longer any connection between the chest and the head registers : she seemed to possess two entirely distinct voices.

It is by going up in chest voice, « en poitrinant » after the usual French term, that one ends by singing in « degueulando » as *Battaille* has so aptly expressed.

It has already been said that the Italian tenor *Donzelli* was one of the first singers to abuse the chest voice. *Duprez* who followed his example was the victim of this way of proceeding; it is known that all his tones were given in chest register. Since then how many tenors, ignoring the lesson, have endeavoured to attack *Sol, La, Si* and *Ut* in chest voice? « They may be seen, purple in the face, veins distended, eyes wet and protuding, fighting until exhaustion, with blind obstinacy, to try and obtain impossible effects » (*Segond*).

In fact, it is not always easy to obtain an homogeneous voice, offering « no gap » and possessing well blended registers, but the professor who knows his art, knows also how to overcome these difficulties. Of old the Italian singing-masters made all their efforts to smooth these registers, so that no difference of timbre should be noticed; but it took them several years to form the pupils. Let us repeat that *Rubini* has thus studied during seven years, and that *Cafarelli* has worked for five years on one single page of music.

It must not be forgotten that the fixation of the larynx, or its inconsiderate lowering, obliging the singer to hold his head bent upon the neck, renders necessarily this change from one register to the other defective, as the organ, deprived of its mobility, is unable to execute the muscular alteration aforementioned which characterizes the break between the registers.

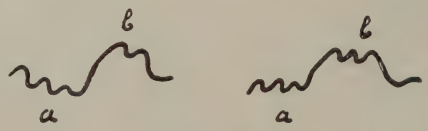

Figure 157.
Graph of the movements of the muscle crico-thyroideus in a tenor having a defective break : *a*, thick register; *b*, thin register.

The following graph (Fig. 157) has been taken on a tenor who made use of this proceeding of bending the head in proportion as he ascended the scale.

If one compares this graph with the one shown on figure 108, page 131, one will easily understand that this way of producing the tone must be absolutely repudiated by the singing-masters.

I have been able to amend this defect by changing the position of the subjet's head, and by advising him to practise exercises exclusively upon the descending scale.

Defective dispositions given to the organs of resonance and of articulation. — From what has been previously said of the importance of a correct position of the organs for producing the tone and obtaining a good articulation, it will be easily understood that if these rules are not followed the nature of the voice will be altered.

Defective production of tone. — I have at different occasions spoken of the sombre voice which so many artists have abused. As the larynx, in this emission, occupies the low region of the neck, certain professors give the advice of using it, under the pretext that by that means one lengthens the vocal tube and increases the volume of the voice. This way of singing offers the inconvenience of accelerating the air current, as the artist is obliged to multiply the inspirations, and furthermore, being forced to blow the air out more vigorously so as to reach the high notes, he spends a greater amount of breath. « Besides, the sombre voice requires, for reaching the shrill notes, a greater contraction of the glottic and a more active expiration » (*Petrequin* and *Diday*).

Segond writes that in the sombre voice, the larynx, kept motionless in the lower part of the neck, sruggles against the forces which tend to raise it during the production of the high notes of the chest voice, and it is only by a vigorous pressure and a great expense of air, that the tones delivered in this manner acquire all their qualities. The respirations must be ample and frequent, in consequence fatigue is apt to appear rapidly. The people who abuse this emission, seem to be screaming rather than singing, thus justifying the criticism of *Scudo* : « one does not sing any longer, but one shouts, or struggles with all the might of one's lungs, and one believes to be a great singer, when one catches, out of the lowest depths of one's interior, a tone sickly and shrill. »

How could it be otherwise with such a position of the organs, which suits for the production of the vowels *o* and *ou*, but is quite inadequate for the emission of *i* and *é*? How can one reconcile two such different requirements? One sings with a tight guttural voice : one *sings in the throat*, as says *Battaille*, who points out that the expression « to sing from the throat » is improper. « One sings with the larynx which is inside the throat, and which lets the vocal tones escape through the throat ».

The voice takes a squalling and unpleasant character. This way of producing the tones demands the stretching apart of the jaws

and lips. Therefore, there is nothing surprising in the fact that *Duprez*, who abused the chest voice, should have opened his mouth so wide while singing. One knows the result of this wrong emission to which he was the first to fall a victim.

The effort required from the organs is rendered apparent by the prominence of the muscles of the neck, which present themselves under the shape of cords strongly stretched underneath the skin, by the congestion of the head and of the pharynx, with granulations and swelling behind the posterior pillars of the soft palate.

In trying to imitate the Italians, whose idiom demands particularly the use of the clear emission, the singer exaggerates the widening apart of the lips, the opening of the mouth, and specially a position of the tongue which is not suited to the formation of the French vowels, without speaking of the antero-posterior lenghtening of the axis of the pharynx which causes the voice to lose some of its sonority and of its reach, and to become blank.

Many singing-masters demand of their pupils, that they keep their tongue motionless and pressed upon the floor of the mouth, under the pretext of thus widening the resonator. Some seem satisfied to ask the students to sing in front of a mirror, so as to follow the movements of the tongue and to try and prevent them; but others have recourse to energetic contrivances to obtain the latter result, making use of a spoon, or of a paper-knife, or even a piece of wood consisting in a stem ending by a ball, which is pressed against the tongue and the soft palate, to the effect of drawing them back! I have known artists who submitted themselves to this treatment! The teacher, who belongs to the fair sex, held two of these tools in each hand, and so did the pupil... A basin was the very necessary complement of this instrumentation.

Other teachers prefer using india-rubber balls which are placed into the mouth.

It is unnecessary to point out the results of such a method which, hindering the play of the organs, makes a good emission and a good articulation quite impossible owing to the obstacle opposed to the displacings of the larynx.

Stephen de la Madelaine was accustomed to give his pupils the judicious counsel of leaving the lips in the same position as when they produced the spoken voice. But often the professors are not satisfied by such a simple process. The ones require that the lips should be kept motionless, and go so far as to maintain them against the teeth by means of an apparatus, for the purpose of obliging the buccal orifice to remain entirely fixed during all the time of the lesson; the others have a method of which one of the fundamental rules is that the buccal orifice should be more than widely open.

This means that they oblige their pupils to use the sombre voice in spite of its fatal consequences, and to neglect the articulation.

It is from the time when the sombre voice became of constant use that the art of singing began to decline in France. Its first victims were *Duprez* and *Nourrit*.

Defective attacks of tone. — The abrupt attack, by real shock of the glottis, causes rapidly the fatigue of the voice, so that the singer is obliged to take a longer rest each time he has sung, so as to restore his voice; he complains even sometimes of hoarseness while speaking. How many young pupils are in the impossibility after a few lessons to pursue their studies! The laryngeal lesion, which provokes this passing aphonony, is often vainly sought for; it is not always apparent in the beginning, but manifests itself by the inability to sing and the fatigue of the organs, fatigue to which the name of *phonasteny* or *mogiphony* has been given, as mention will be made to in due course.

The sound which was correct gets out of tune; the subject can no longer sing softly on the high notes, dissonance occurs; the sound is broken short before reaching the required duration : this is the *rupture of sound* or *the thread in the voice*, after the usual expression; the tone can only be delivered by means of straining, and even then it is kept only for an increasingly short time. The purity of the voice is replaced by tremolo and quavering. The vocal cords get congested and even thickened, a nodule becoming apparent on the side (especially in tenors), or else a swelling of the median part of the cord occurs, presenting itself under the shape of a fusiform lengthening.

As for the singers who have taken the habit of uttering the tones on the breath (weak attack), I have already indicated the respiratory disorders which they feel, and the difficulty they find in attacking the note in tune, being inclined to take it below the pitch.

If, in the beginning, the lowering of the note is not perceptible to the ear, it can be clearly observed on the phonographic graph which shows that the sound does no longer keep in tune during its emission : a few periods are missing, then the equilibrium is restored to be broken again and to produce a tremolo. Thus, in trying to utter Ut^1, which has 522 periods, the singer utters in turn : 510, 515, 522 periods, falls down below to the tone and goes up again to 522..., as is recorded on the graphic (Fig. 137, p. 168). Even a trained ear does not notice immediately this diminution of periods in the note, it is only when this difference is more accentuated and is as considerable as a quarter of a tone, or a semitone, that one has the impression the subject is singing not in tune.

In the category of the defective attacks can also be ranged the phenomenon, which takes place in what is called « *singing on the timbre* », which is used to recommend the tightening of the vocal cords, for the purpose of giving mordant to the tone, which is about to pass into the upper-laryngeal cavities. This process is simply an attack of the tone by shock of the glottis tightening of the throat. The congestion and the formation of granulations on the lateral part of the pharynx, the development of nodules, or the swelling of the border of the vocal cords, so as breathlessness are the ordinary consequences of this incorrect emission.

Props. — I have previously explained what was meant by the term *prop*. The prop is in fact the sensation felt by reason of the passage of the breath at the generative orifice of the sound : thus the palatal prop. But it is an error to give to the word « prop » the meaning of contraction and resistance, and this mistake is not without importance for the singer.

When one says : *bear on the chest*, one seems to require that the midriff and the lower ribs should take their fulcrum on that part of the thorax; this prevents the normal play of the expiration and impedes the breath pressure necessary for the formation of the sound. This way of producing the tone provokes the *prop on the throat*, or *in the neck*, which determines the lowering of the larynx, the contraction of the pharyngeal muscles, and gives a stifled voice, without timbre, sunk and guttural, accompanied by all the pathologic consequences afore described.

To take a prop in the mask, in language of song, means *to place the voice between the two eyes*, or simply to make the tone sound in the cavities of the nose.

The impression of resonance in the nose is due to the propagation of the sonorous waves of the mouth through the bones of the palatal roof. The bones are very good conductors of the sound, as can be verified by placing a tuning-fork in vibration on the top of the head; it is most clearly heard, and the sound is even reinforced if one shuts the ears.

The lack of anatomical and physiological knowledge is responsible for the use which is made of these words, which have no meaning whatever from the scientific stand-point. As a reference to the study of the production and of the formation of the vowels will make it easy to ascertain, for according to the degree of opening of the velo-palatal sphincter, the sound passes or does not pass through the nasal chambers, the air being only set into vibration.

Certain singers by the words *prop in the mask*, designate the *half-tint* which, demanding the raising of the larynx, that is the same position of the organs as required for the emission of *i* and

consequently the raising of the soft palate, thereby proves that the tone does not pass through the nasal chambers in order to obtain this emission.

Defective position given to the organs of articulation. — To sing as one speaks ought to be the chief care of the artist whose voice has all the requirements needed for a good articulation. But this truth is too simple to be accepted without discussion.

« These two calamities : an elocution which abolishes the song, and a song which disregards and paralyzes the elocution, both spring from the same error which consists in believing that song and elocution are two distinct and superposed matters, when in reality they ought to form an indivisible body, depend closely from one another, and help each other mutually » (*Reynaldo Hahn*).

I have sufficiently dwelt on the way of singing which is effected by bringing down the neck or the lower jaw with every descending note, or by raising them with every ascending note, for the purpose of giving the vowels the same capacity when they go down as when they go up. *Lefort* has advised this process. It is no longer the vowel which requires a modification of the buccal cavity, but the note.

The teachers of the great Italian school of the XVIIIth century had clearly pointed out the necessity of producing the tones normally. In 1723, *Mancini* wrote : « The rules relative to the position of the mouth which are often considered as unimportant, are however absolutely essential for succeeding in the art of singing... The inordinate opening of the mouth is the cause of the voice being in the throat. »

Many professors, who have their own particular system of tuition, demand that the sonority of all the vowels should be assimilated to the sonority of *a*; but they are as badly mistaken as the teachers who wish to sacrify everything to *e* or *o*. *Stephen de la Madelaine* stands up against this process : each vowel must be given its characteristic aspect.

Faure is not afraid to say that the singers work against their own purpose in trying to avoid certain shut vowels, like *i*, *é* and *u*, and in inventing fancy sonorities for their personnel use, as the shut vowels offer more solidity to the tone than the open vowels; those who have resolutely attacked them at the beginning of their studies, instead of shunning them, have on the contrary a kind of predilection for them; they appreciate their support, their security and their property of opposing themselves to the deperdition of sound.

Dr. *G. Richelot* has perfectly well observed that the singers juggle with the *i*'s and *u*'s, because they do not know the way to produce them; they alter the vowels to make them ring more, and

think it ingenious to round the voice and sink it, singing like water-carriers. All these mad and arbitrary contractions, at the same time as they offend the ear, end by causing the fatigue of the vocal apparatus and by wearing it out.

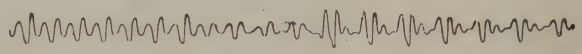

Figure 158.
A sung on *Ut*[4] altered into *O* (abuse of the sunk timbre).

A reference to Figure 158 will prove the precision of this observation. This graph has been taken on a young girl whose voice was sunk, owing to the fact of changing *a* in *o*. She herself has sunk, when the time came for her to pass the competitive examinations of the Conservatoire!

There is no reason to be surprised if singing-masters recommend to use of this system of deformation of the vowels, when a former doctor of the Conservatoire, himself, has no hesitation in making the following statement : « If even at the price of ungainly attitudes, you cannot succeed in making the tones, which come from the larynx, agree with the production of certain vowels to attain the musical end, recurrence must be made, as you well know, to other vowels » (*Gouguenheim*).

The same author adds that to give more charm to the timbre, one is obliged to alter the conformation of the mouth and tongue, organs which are necessary for the utterance of the consonants, and furthermore one is sometimes compelled to subject certain consonants to a change of articulation, so as to give the timbre a more agreable character.

When such counsels are given, how can one be astonished to hear a gibberish which is in no way pleasing to the ear : « Grand Diô... mon keir... ç'ata les palmes immortalles... Vians môrer... laisse mo parter... pelaisir d'amor... Ekelat de la guerandeur. » E-un so-ar t'u-an souvia-int-il?

Instead of : Grand Dieu... mon cœur... c'étaient les palmes immortelles... Viens mourir... laisse-moi partir... plaisir d'amour... Eclat de la grandeur... Un soir, t'en souvient-il?

It requires certainly a greater effort to alter the tones in that way, than to pronounce the author's words correctly. It is a good thing to bear in mind the following observation which rests on experience, viz., when a group of muscles is necessary for the execution of a difficult exercice which is outside the ordinary or the instinctive habits, the muscles do not display the required strength; furthermore others which are quite useless are set into contraction, thus disturbing the function of the really indispensable muscles.

This can be applied to people who sing without rules. The bucco-pharyngeal cavity takes arbitrary positions, which do not correspond to the normal positions, hence the disorganisation and the anarchy in the working of the organs.

I have already quoted that *Emilio de Cavaliere,* in the XVIIIth century, considered the music to be tedious from the moment the words were not heard.

Tosi, also, admits that : « For lack of a good pronunciation, the singer deprives his auditors of the charm which the words add to the song, and suppresses both truth and strength. When the words are not distinctly heard, one is unable to make the difference between human voice and the sound of a hautboy or of a cornopean.

Reynaldo Hahn protests with a keen sense of humour against this fatal deformation of the vowels, and says that « in an act which takes place at Venice, the words of a barcarolle are pronounced in such a way, that one is tempted to believe that by an excess of concern for local colour, the diction has made this barcarolle to be sung in Italian ». He adds that he cannot help being surprised that « spectators should still suffer in lyric theatres, the defective pronunciation of the singers, which renders the play represented before them quite incomprehensible. How is it that no protests should be raised against this kind of muttering, and the gabble which prevails everywhere nowadays ».

Ch. Delprat was perfectly right in remarking « as regards the pronunciation of the words, I may say that the really clever artist, whose throat will have become entirely independent from word, and the latter equally independent in its turn from the throat and its movements, yes, I dare say that this singer will find that in song, the difficulties of pronunciation are far less than one generally contends ». In speaking thus of the independence of the organs, this author seems to suggest that the pronunciation must be considered before anything else, the organs coming from themselves to fill the required position.

To pronounce distinctly and, consequently, to sing well, it is necessary that the vocal apparatus should be supple, that is to say that none of its parts should be in a state of contraction.

Attention must be given to properly practise the movements which supple the neck, by carrying the head, without roughness, downwards, to the right, to the left and slantwise, one endows the muscles near the larynx with a suppleness which facilitates the movements of that organ. Other very useful exercises are those which supple the tongue, especially for singers who find some difficulty in giving the position required for the utterance of the various vowels.

These exercises should be done thus : draw the tongue sligthly forward, then backward; carry it to the right, to the left and upward, giving special care to the movements of the tip; bring it against the roof of the mouth behind the teeth, then backward, lastly between the lower incisives, arching or flattening its horizontal part.

One must also practise exercises so as to supple the lips, and thereby give tonacity to the muscles which govern their movements.

I will also never sufficiently advise to be mindful of singing on the different vowels, varying the note and keeping the jaw-bones more or less apart.

As previously explained, it is not the lips which give the vowels their characteristic, but the lesser or greater degree of the generative orifice of the tone, orifice formed by the roof of the mouth and the tongue, the latter approximating more or less with the palate.

Exercises practised with shut mouth facilitate the displacings of the tongue, in the utterance of the different vowels, to those who do not know how to place their tongue properly, with regard to the roof of the mouth, at the same time as they make clear emission easy, as the muscular contraction, which is necessary to keep the mouth shut, prevents the tightening of the posterior parts of the pharynx; this would happen if the muscles of the latter and those of the neck were to contract, thereby hindering the movements of the tongue, of the lips and of the front part of the jaw.

It is an excellent way to prevent the production of guttural sounds, sounds which give a disagreable timbre to the voice and, at the same time, render the articulation quite incomprehensible.

Nasal voice. — We think it necessary to explain in finishing, the meaning of the expression : *nasal voice.* It is indispensable to make quite clear what these words are intended to convey : Do they mean that the air current passes through the nose or, on the contrary, that it does not enter into it?

When the nasal chambers are stopped, no resonance is produced in these cavities; the expression « to speak or to sing from the nose » is improperly used to express this absence of nasal resonance.

On the contrary, if the sound passes through the nasal chambers when it ought not to do so, an excessive resonance of the air, inside these rigid walled cavities, takes place.

In French, the difference is expressed by saying in the first case that « *on nasonne* » and in the second, that « *on nasille* ».

In the latter intance the soft palate is relaxed; it comes nearer to the tongue so as to let the sound escape through the nose.

Insufficiency in the matter of studies. — *Oscar Comettant* says that the singers of the great Italian School made most of them very long careers; they song for thirty or forty years, keeping a voice always

pure and well pitched. Actually, a tenor who resists for a period of ten years to the « régime » of grand operas, is a solid man and is spoken of as an exception. Rubini, the last and the most admirable representative of the great Italian School of the XVIIIth century, has sung in all the capitals of Europe during thirty-four years, without his voice ever losing any of its power or of its incomparable flexibility.

But few are nowadays the artists who stay on the stage for thirty years. However some are known to have been able to make a first class career, which reminded the one of the most celebrated singers of the Italian School.

Gustave Bertrand writes : « It is not a question of mere chance, if most of our singers lose their voice after a few years, whilst the Italian singers of the ancient school kept theirs indefinitely. The reason is that the professors of old, paid great care to hygiene and to the fine emission of voice; the pupils were not allowed to sing scenes out of operas, before having made their organ flexible by means of these vocal gymnastics called vocalization. »

« But now the preoccupation is different. As soon as a pupil is in the hands of certain professors, these start by making him learn the tune of *Lucie,* or the duet out of *The Huguenots,* without heeding whether this kind of studies tires out the ill pepared voice, or if this voice exhaust itself in trying to render effects of feeling, when the emission is hardly sure yet; the voice is young, it will always last at least three of four years, and that is all which is required to catch a prize or two ».

Oscar Comettant says further : « The singers nowadays do not practise any longer the art of singing. Ten years were needed before to form an artist capable of taking the leading parts in Opera; but now only a few months are necessary to make any butcher-lad, with a voice, fit to fill the same functions. He sings without any method, it is true, his elocution is bad and he plays awkwardly, but from time to time he utters a vehement note as one fires a gun, and the public applauds, glad of enjoying a good voice, if not a good singer. »

The responsibility of the initial fault with regard to the insufficiency in the studies rests upon the singing schools, where the elementary principles of lyrical art are practically disregarded.

To practise arpeggio, to make exercises upon a vowel, to hold the tones without either diminishing or increasing them, and to study solfeggio, all this is considered nearly as sheer waste of time. The pupil who enters the Conservatoire has only one object : to get an engagement in a subsidized theatre; therefore his chief preoccupation is to learn tunes and practise staging.

It is obvious that if, at least, one year was given to the study of the elements, and if before entering the singing classes, the pupil were to pass an entrance examination proving that he is able to study a tune, the level of the tuition would be higher.

Of old, boarding was compulsory for the pupils who had therefore no material cares; but now to be able to live, the students are obliged to play in no matter what theatre; they even often absent themselves to go and perform out of town. How many have I seen exercising a profession that had nothing in common with song! How can their studies be serious under these conditions?

Besides, as soon as they have entered the Conservatoïre, they have quarterly examinations where they have to sing a tune, and competitive examinations for which they are obliged to prepare several pieces.

The result of this teaching is : a bad pitch and holding of tone, a defective breathing, an improper emission, tremolo, a wrong attack... as shown on the foregoing graphs.

To-day, trade takes the lead over art : voices are made to be sold to the best bidder. Therefore one dreams of making quick studies, encouraged, it is true, by alluring advertisements which promise to form artists in a few months!

But there is a reverse side to the medal. Those who ignore the principles of singing will make only a short career, and their decline will come rapidly.

It is surprising to see the quantity of young pupils, laureates of our French Conservatoire, who pass through our theatres. They come out of the Academy with incomplete notions, and a conceit which gives them an extraordinary self-possession; but this, unhappily, does not replace the knowledge of acting; once on the stage, they refuse to take the smaller parts which would enable them to improve, by contact with artists of renown, and to learn their business. They want to approach immediately the leading parts, without realizing that it is study and experience which help to make a reputation. How many of these shooting-stars, though sufficiently gifted to make an honourable career, have been compelled to abandon the stage and to give themselves up to the professorship, or else to choose another trade!

Overwork of the voice. — Many pupils imagine that they can work without danger for several hours and sing several partitions. This is the usual process of arriving promptly at vocal fatigue. I have sufficiently dwelt already on the question of the length of time which must be given to practice.

The artists are sometimes unable to restrain themselves from abusing their voice. They believe that it is possible for them to

rehearse in the afternoon, and to play in the evening; besides that, to study at home so as to increase their stock-pieces, also to sing alternately parts like *William Tell* and *Rigoletto*, thus passing the limits of their voice, in their endeavour to obtain a part which is outside their natural means. But by doing so, they undertake a task which exceeds their powers, and causes serious accidents as paralysis of the vocal cords, congestion of the organs and even vascular rupture, several examples of which I have had the occasion of observing, on the vocal cords of artists who had risked similar unlucky feats of strength.

CHAPTER XVIII.

VOCAL HYGIENE.

Clothing. — The singer must not wear impermeable clothes which condense the perspiration and keep the body in an atmosphere of damp heat. If he is inclined to perspire, it would be advisable for him to wear flanel directly on the skin, or a cellular vest.

His clothes must be made of light and soft stuff which help the slow and imperceptible evaporation of the cutaneous perspiration.

He must avoid scarfs, but must protect the nape of the neck and cover the neck in a light and loose way.

Women must not compress neither waist nor abdomen and, consequently, must cast away compressive stays. The aim of the stays is to support, and not to squeeze the organs; they must leave their entire freedom to the movements of the base of the chest and of the stomach hollow, so as not to hinder the respiration.

Certain artists make use sometimes of a belt to maintain their abdomen; by this contrivance they remedy the lack of tonicity of the abdominal muscles, which is further developed through stoutness. The drilling exercises, which have been previously enumerated in connection with the respiration, will remedy this inconvenience.

Diet. — As azotized food, preference will be given to meat over game, as it is more easy to digest when slightly cooked; poultry and fish, though digestible, are however less nutritive; ham is of easy digestion; broth and clear soup are less nourishing than gravy; chicken is an essentially respiratory aliment, as well as butter and whey. It is advisable to abstain from eating salted or fermented cheese which irritate the throat and make one feel thirsty, fresh cheeses have not that inconvenience. Eggs contain very nutritive substances, and also some oily parts which make them a respiratory food. There are however people who are unable to eat them without suffering from intestinal poisoning.

The substances which come from the vegetable kingdom, are preeminently respiratory aliments, as they contain fecula, gum, sugar. Potatoes, rice and tapioca are commendable respiratory aliments which enter the category of nutritive aliments.

If bread is a good aliment, pastry-cook is not.

Vegetables, as a rule, are easy to digest; however some must be excepted, as cabbages for instance, because of their great amount of filaments. Dry vegetables (beans, lentils, broad beans, peas) have also an envelope which is difficult to digest. Green vegetables, when they are well cooked are not very nourishing, but refreshing and digestible.

All the fruits are good, with the exception of acid fruits, nuts and almonds which contain oil irritating for the throat.

Condiments must be used with discretion.

Sugar and fruit sweets are essentially respiratory aliments.

Fresh and limpid water, of agreable savour and free from organic matter, is an excellent and hygienic drink. One must avoid drinking iced water, especially if one is in perspiration, as this can give rise to laryngitis and consecutive aphony; hot water provokes perspiration.

Natural wine in small quantity is far from being harmful; preference ought to be given to Bordeaux wines. Fermented drinks (brandy, beer and sparkling wines, in which the fermentation is not complete), have an action so much the more unfavourable upon the mucous membrane of the arterial ducts, as they contain a greater quantity of alcohol.

If tea and coffee are excellent tonics and stimulatives, they act upon the movements of the heart, and accelerate them to the point of causing violent beatings, at the same time as they increase the frequency of the respiration and make the voice short and panting; therefore they must be used with moderation. Grogs and punch, like Champagne, provoke a momentary excitation followed by the depression of the organism, hence these drinks must be avoided the day the artist is giving a performance. Lastly, acidulated syrups (fresh lemonade and orangeade, red-currant syrup), diluted in a sufficient quantity of water, refresh the mucous membrane, but bottled lemonade must be left aside.

As it is necessary that the quantity of nutritive and respiratory food consumed, should be proportionate to the expenditure of the tissues, the diet must not be insufficient, this occurs unhappily too frequently in some cases, with the result that the breathing slackens, and the voice grows fainter with the debatement of the strength. On the other hand, table excesses must be avoided.

It is difficult for an artist to have regular hours for his meals; he is often obliged to change his habits, so to avoid singing during digestion as the stomach, being then loaded with food, would impede the movements of the midriff.

However some artists have made an exception to this rule, thus *Malibran* supped in her dressing-room, half-an-hour before going on

the stage, dressed as Desdemona or Arsace, she ate mutton chops which had been brought to her from the « Café Anglais » and moistened them with half a bottle of Sauternes! After her meal the famous singer used to smoke a cigarette, throwing it away just when she was called to the stage.

Speakers and singers will eat two or three hours before speaking or singing; they must remember that fat must take a greater place in their alimentation than in ordinary diet.

The artist can eat after having sung, but it is advisable for him to wait a short time before doing so, so as to let the artificial congestion, which has been provoked in the vocal apparatus by singing pass away.

Residence. — If he can possibly do so, the artist should occupy a house sheltered from cold, wind and dampness. He should give the preference to a sunny dwelling, his room should be well-ventilated and turned to the south, and have neither hangings on the walls, nor carpets.

As to the mode of heating, preference should be given to the steam vapour heating system; the hot air apparatus must be avoided as it lets out dust and smells and provokes the dryness of the throat, an inconvenience which can be partly remedied by means of a wet towel placed around the hot-air pipe. In fire-places, wood and not coal must be burnt. Portable stoves give a disagreable smell and let deleterious gases escape.

As regards lighting it is preferable to use oil lamps which give no smell, or better still electric light rather than gas which changes the oxygen in carbonic acid.

Perfumes. — The ill-effects which perfumes have on the voice of certain singers is well known. An instance of this fact is given in the following anecdote : *Marie Sasse,* who was singing in a private house with an artist of the Italian theatre, was begged by this latter who was rather in a hurry, to let her sing first. *Marie Sasse* acquiesced, and to thank her, her comrade gave her a splendid bunch of Parma violets which had been sprinkled with a heavily scented violet extract. The effect was instantaneous : after having smelt it, *Marie Sasse* in coming on the stage was aphonous. It is because of this harmful influence perfumes have on the voice that it is forbidden, in certain theatres, to bring flowers in the artists dressing-rooms.

Another story is told of a lady singer who was wearing on her bodice a bunch of orange blossoms, the smell of which strongly inconvenienced her partner. The latter, unable by any kind of supplication, to decide her to change these flowers against artificial ones, ate a fair quantity of garlic : the result, it appears, was magic!

These pernicious effects of the odours on the voice has been pointed out by many practitioners (*Hiley*, in 1841, *Orfila*, *Guersant*, *Cloquet*, etc.).

Sleep. — The singer is advised to sleep in a room away from noise, secluded and dark, and to give about eight hours to rest. Day sleep cannot be compared to night sleep.

Faure relates that he slept a little after his meal, in waiting that the time would be up to go to the theatre; but this must not be done when one sings in an evening party, that is about half past ten or eleven o'clock. Sleep taken at the approach of night time is always deeper, says *Faure*, and one feels heavy when one wakes up.

We certainly do not advise artists to recur to such a proceeding, which often gives head ache and also dryness of the throat, if the subject is inclined to breath through the mouth.

Exercise. — The artist should walk for an hour or two, daily, at a moderate pace.

Tennis and fencing are excellent means of giving vigour to the muscles, and of developping the chest. In addition, exercises of pulmonary gymnastics should be made.

Fishing is an unsatisfactory form of sport, as it exposes to cold. When shooting, over-fatigue, perspiration, risks of catching a chill, rain should be avoided, and also... the clumsy neighbour's shot, with which several artists from the Opera have made a painful acquaintance!

The principal recommendations which must be borne in mind by artists desirous of keeping their voice in healthy condition are : not to sing in the open air; not to indulge in smoking, and to be specially moderate in the use of cigarettes, of which the smoke is swallowed, finally to shun sexual excesses.

The Ancients took great care of their voice. *Debay* relates that the orators, the dramatic artists and the singers of Athens and Rome resorted to a thousand means to obtain a clear and sonorous voice. They would never have uttered one word in the morning, before having methodically delivered first the tones of the middle-voice, then the deep tones, and lastly, the high ones. The singers in getting up began by producing the tones, as near gradually as possible, so as to avoid straining the vocal organs by requiring of them a too abrupt display of strength; they even kept lying during these exercises, and only got up after having run several times over the scale.

Martial, Perse, Juvenal, speaking of the precautions taken by speakers and singers to preserve their voice, say that they cleaned their throat and nasal chambers with various plant infusions.

Dioscoride and *Pline* indicate about twenty different plants and as many receipts for embellishing the voice.

Suetonius relates that *Nero* placed a sheet of lead on his chest, when he practised declamation and singing in private. He used to take away this sheet when he appeared in public : his chest being freed from this obstacle, his voice came out full and sonorous, in all its beauty.

Aristotle, Cicero and *Apuleius* are unanimous, concerning the precautions taken by orators and singers, in their endeavour to develop and keep their voice. *Seneca,* the elder, reveals the thousand superstitious devices common amongst them.

Lastly, *Quintilian,* the orator, tells us that the Ancients had made thorough studies as regards to the human voice and the devices which favoured its perfect development. According to this author, vocal art had become at Rome a profession lucrative as well as honourable.

The adjuvants of the voice. — An artist who is making his debut, is generally very anxious to know what he can drink during the performance. He fears the dryness which the usual nervousness of a first appearence on the stage increases. A small drink of water, or a throat bath with a light alkaline solution, like *eau de Vals*, suits generally this purpose of moistening the mouth.

It is better for the artist not to over-charge his stomach in the course of the performance, and not to indulge in strong drinks, nor in iced drinks specially, as the latter are apt to produce sudden hoarseness.

If at the end of the representation, he feels the need of taking some food, let him be contented with broth (not too fat) and with an egg, and avoid a more substantial meal.

CHAPTER XIX.

THE DISEASES OF THE VOCAL ORGAN.

If there is a category of people who, by reason of certain lesions of the vocal organs, as congenital ill-formations (hare-lip, perforation of the palate, shortness of the palatal roof, etc.) are unable to addict themselves to singing, there is another which ought to be submited to a medical visit : I am speaking of the people who breathe through the mouth, who have a dry throat in the morning, etc. It would even be most useful to oblige everybody destined to the theatrical career, to pass before a board of examination which would consider the condition of the vocal and respiratory apparatus. Thus one would be able to ascertain the existence of ailments which are far from being rare (deviation of the nasal septum, tumefaction of the turbinated bones, adenoids, granular inflammation of the throat, enlargement of the tonsils, etc.), and which provoke the obstruction of the naso-pharyngeal cavities, also respiratory disorders and diseases of the throat, compelling the pupil to interrupt his studies frequently.

I take here the opportunity of condemning the deplorable habit which some people have of washing their nasal chambers daily, or of inhaling water through the nose, also of gargling and throwing the liquid out again by the nostrils. Nature has disposed on the mucous membrane of the respiratory ducts, means of protection against dust : the vibratil cilia which cover the epithelium over. Washing only destroys them and exposes those who use this process, to precisely the same accidents which they wished to avoid. The nose gets stopped, the mucous membrane becomes swollen, and secretes mucosities which are apt to inconvenience the singer when they fall in the back of the throat.

Cauterizations by means of galvano-cautery, encounter serious opposition on the part of many singers, who have been strongly encouraged in that ill-founded fear, by a theatre director who advised his artists, specially the women, to refuse having any firing needles put in their throat, for, according to him, in women the voice is formed in the pharynx, and in men, in the larynx, hence the danger of touching the throat of the former.

Cauterizations must always be done lightly. I have indeed seen several times the consequences of a cauterization made too deeply, by unskilful hands; in such cases, an adherent scar is formed in the subjacent tissues, which prevents the slipping of the pharyngeal mucous membrane, and therefore occasions a disturbance in the movements of the organ so necessary for the production of tone.

One must not hesitate to remove the adenoids which obstruct the cavities of the nose and render the voice snuffling. They not only cause disorders of the respiration, which is then insufficient, but they also determine an ill-formation of the thorax, to which the name of careen-shaped chest has been given. Once they have been extracted, the air passage is reestablished; the sufferer feels an impression of welfare unknown until then; his voice loses its cottony quality and becomes well « timbred »; sometimes also the tessiture rises.

On this subject I have observed a remarkable case which concerns one of the most distinguished artists of the Paris Opera. At one time he felt such a great difficulty in singing his parts, that he longed to be at the end of his engagement and to leave the stage. But after the ablation of the adenoids which encumbered his pharynx, this artist gained two notes in the thin, and was enabled to play several operas which required a high barytone tessiture.

Likewise it is indispensable to take away the obstacles which stop up the nasal chambers and determine an encumberance, the inconveniences of which are better realized when it has been got rid of operation. I have practised on many artists the partial ablation of the nasal septum, or of the turbinated bodies, I have never observed any troubles consecutive to these operations; on the contrary, the result has always been a considerable amelioration of the voice, as regards both to breath and timbre. It was after an artist had undergone a similar operation, that his director remarked to him : « It is astonishing how for some time your voice has absolutely suited the room! » The artist had simply a more sonorous voice.

Let me cite also the case of a tenor from the « Opéra-Comique » who was unable to sing any longer, owing to the considerable enlargement of his turbinated bodies, and who gained a minor third after having been operated, in consequence of which he obtained an engagement at one of our principal lyric stages to sing Wagner. One thing however surprised greatly the artist a few days after his operation : « I cannot pitch my voice as I used to! », was his complaint. But I made him observe that his emission had been wrong before, on account of his nasal obstruction, and had now to be altered. He began studying again; his voice developed and his timbre improved so tremendously, that his new director expressed

his astonishment that such an artist could have been kept away from the foot-lights.

If the ablation of the tonsils has become necessary, out of the fact of their considerable enlargement which renders the elocution thick, and gives the voice a dull, cottony, guttural timbre, the practitioner encounters often serious opposition on the part of both teacher and pupil who fear that the timbre and the high notes will disappear. They have got no further than the story, already old, of Count *Fredigoti* who, it appears, having had the two thirds of his tonsils taken away, so as to give greater purity and compass to his barytone voice, lost four high notes and won instead two deep ones, acquiring at the same time a clearer and rounder timbre. But in this special case, the objection could be made that the voice was perhaps wrongly pitched; furthermore the operation had not been complete, and probably similar lesions existed in the pharynx and the nose as well, lesions of which one was not aware at that time. However in opposition to such cases, one could cite the examples of *Louisa Pyne, Adelina Patti, Lucca*, etc., to prove that far from provoking a disorder of the voice, this operation has, on the contrary, the effect of facilitating breathing, articulation and emission and, at the same time, of improving the timbre.

A few years ago, it was the fashion of snipping the uvula. Every singer whose organ was slightly elongated, had recourse to the guillotine which some practitioners handled too freely. In the course of my career, I have seldom had the occasion of practising this operation which, in my opinion, must be reserved only to uvulas of exaggerated length, provoking a tickling of the lid, and thus determining fits of coughing. Our German colleagues were of the same opinion and did not find it advisable to make this resertion, especially at the time when scissors only were employed, the use of the galvano-cautery being still unknown. Several serious hemorrhagies, consecutive of this operation, had cooled the zeal of some of them.

If these diseases, which have just been reviewed, are already existent before the subject starts the study of singing, they constitute a serious obstacle to his profession and ought to be treated radically.

Some other ailments, like the common head cold, amygdalitis, laryngitis, trachitis, bronchitis, without being particular to the singer, provoke vocal troubles which would perhaps not need special attention, as far as ordinary people are concerned, but which inconvenience him in the practice of his art; for such cases artists ask from the doctor for an immediate cure, so that they may go on with their series of representations. How often have they been able to save their salary, by submitting themselves to a treatment which

relieved the congestion and left them in entire possession of their means, without their having to fear a consecutive aphony of several weeks, as I have many times observed in instances, when certain medicaments (like aconite) in strong doses, had been inconsiderately used upon the counsels of the theatre manager who, being anxious that the performance should take place at all costs, cared little for the possible vocal troubles of his too trusting artists.

Constant attacks of cold in head and bronchitis which recur frequently, are generally due to a persistent disease of the nasal chambers; it is therefore desirable to search in these cavities for the cause of these ailments.

Nasal catarrh occasions the hypersecretion of the coverings of the nostrils; the mucus falls in the pharynx and provokes a frequent need of expectoration. If the nose is stopped during the night, the sufferer breathes through the mouth, and in the morning his throat is dry.

The tracheal catarrh equally produces a secretion which engenders the necessity of clearing the voice. In walking up, especially in damp weather, the voice is hoarse and clears up only after the expulsion of the pharyngeal and tracheal mucosities.

As regards the treatment of this ailment, let us say that an excessive abuse of subcutaneous punctures is made, in spite of the fact that they can have ill-effects, as they are apt to determine abcesses. The same remark can be made of oily injections of medicaments which do not penetrate into the parts which ought to be reached; therefore, as a rule, I prefer recurring to nebulization which produces a very fine spray of aqueous or oily solutions.

The nebulizations have the advantage of carrying into the entire lung and the bronchia the medicament which, under the form of a liquid solution, does not manage to penetrate the upper parts of the pulmanory organs which can only be reached by the sprays produced by the globe nebulizer.

Another ailment, which is the cause of rather annoying troubles for the sufferer, is *lacunal amygdalitis*. In this case, the cryptae of the tonsils contain small yellowish balls which give rise to an offensive breath. If they are crushed, they exhale a fetidness not unlike the smell of putrid cheese. They can engender abcesses of the tonsil, and specially impede the movements of the soft palate, for they are often to be found at the upper part of the tonsil which they cause to swell; they also give rise to a constant irritation of the surrounding mucous membrane.

A disease which has an important effect on the vocal organ, as it interferes with the formation of tone, is *the enlargement of the lingual tonsil*. It prevents the working of the lid which ought to rise for the utterance of *é* and *i* and the emission of the shrill

notes. Besides the difficulty, caused by the friction of the side of the lid against these enlarged masses, which this cover finds in taking the position required for the production of the determined tone, a painful irritation arises from the uncessant titillation of these two neighbouring parts, tickling which provokes fits of coughing and hoarseness, and thereby makes it absolutely impossible for the artist to sing.

The abuse of alcohol and tobacco, the smoke (of cigarettes in particular) determine congestion of the throat. The use of iced drinks can give rise to laryngitis.

Let me repeat that certain smells provoke headaches and even sudden hoarseness which render the artist incapable of uttering a sound.

Excesses in diet, irregular meals occasion disorders in digestion, which reach upon the respiration. Defective circulation, certain nervous phenomena bear upon the voice; thus stage-fright, or « trac » which causes irregular breathing and determines also convulsive movements of the jaw, hence tremolo.

The artist is still subject to a last group of ailments which take their origin from the ill-use of the vocal organs.

Nose. — Let us mention first a disease of the nasal muscous membrane, determined in a way by breathing through the nose being carried to a degree of exaggeration. It is brought in the following manner : certain singing-masters, to teach their pupils how to breath, take a forced inspiration, shutting the mouth and drawing the air in vigorously, and throwing it out afterwards by means of a rapid and noisy expiration. The consequence of this effort is to produce, after some time, a relaxation of the mucous membrane of the lower turbinated bodies which floats, giving the illusion of being a sessile polypus.

Pharynx. — The fact in singing in the throat, in using the sombre timbre or the guttural voice, and of making excessive efforts to bring out the tone, determines a congestion of the lateral walls of the pharynx and *lateral* pharyngitis.

This disease is a kind of granular pharyngitis, located to the wall of the pharynx, situated behind the posterior pillars. The swelling can spread to the orifice of the Eustachian tubes, and thereby give rise often to noises in the ear and to a diminution in the hearing. The persons suffering from hypertrophy of the turbinated bodies, and also arthritics (who are very liable to congestion) are more easily subject to this lesion. The position of this swelling on the level of the soft palate, interferes with the correct working of the posterior pillars; the artist suffers a difficulty to hold the tone; he notices that the notes of the break are bad, and the half-tint is altered; often even this compression of the granulations, between the

posterior wall of the pharynx and the pillars, is so painful that it disturbs the production of the tone, especially in the high notes, and produces tremolo.

Women, who make use of clavicular breathing, are also subject to this form of granulations. The muscular effort, necessary for producing the inordinate raising of the upper part of the chest, give rise to congestion of the head and neck, which occasions later lateral pharyngitis.

Certain of these granulations which are separated and situated on the sides of the pharynx, near the edges of the base of the tongue provoke frequently titillation, pain, cough and even aphony. These granulations are sometimes so tenuous that they can hardly be seen, specially as they are hidden in a fold of the mucous membrane, which runs from the lateral edge of the base of the tongue and spreads over the pharyngeal wall.

If one is not able to detect them, one is inclined to consider as a neurasthenic the sufferer who is acutely conscious of the pain he endures, specially when these granulations are inflamed, as they determine painful tinglings.

In the treatment of these granulations, nippers must never be used, as the surrounding mucous membrane would be cut at the same time as the small tumour which is often no bigger than a grain of millet; thereby cicatricial adhesions with the lateral wall would be possibly provoked, and consequently the working of the voice would be impeded.

I have had the occasion of observing such an instance in the case of a tenor from the Opera, about whom there was much talk some years ago. Instead of following my advice and having the small granulations got rid of, by means of light cauterizations, this tenor decided to have done with them all at once. After having seen several practitioners who all agreed my opinion, he finally discovered a doctor who, taking hold of nippers, extracted at the same time the granulations and the neighbouring mucous membrane. In consequence, the border of the horizontal portion of the tongue became joined to the lateral part of the pharynx, creating, besides a rather acute pain caused by the movements of the throat, such a difficulty in singing that the unfortunate artist was unable to use his voice any longer. Ashamed and repenting, he came to see me, to ask some relief to his trouble which prevented even the movements of deglutition. I observed on the left side of his pharynx, on the level of the lid a cicatrical ridge, shaped like a pigeon nest. After it had been cut, the pain provoked by deglutition vanished, and the sufferer was able again to take food without difficulty. His voice recovered; however this singer who used to yodel very easily before his operation, could no longer do so. He failed courage to come

back again on the stage, fearing parts of a certain length; nevertheless every year he made a series of records on the phonograph.

Granulations, hidden beneath the posterior pillar of the soft palate, are capable of exercising disorder in the mechanism of the voice, during the passage from one register to another. This is understood for the granulation, compressed between the posterior wall of the pharynx and the pillar, impedes the movement of the soft palate which finds great difficulty in reaching the high position required for the production of tone.

This is also the reason why *i*'s and *é*'s are delivered with less ease than the other vowels, which demand a less approximation and a lesser raising of the solft palate.

If these granulations get inflamed, the disturbance can become painful.

After they have disappeared, the artist is surprised at seeing the passage of the voice become normal again.

In certain cases, small varicose dilatations are observed on the base of the tongue; under the effort arising from the fact of singing in the throat, they inflate and sometimes break, giving way to some streaks of blood which are found mixed to the expectorated mucosities; this never fails to frighten the artist who, immediately, believes that he is consumptive. The enlargement and specially the rupture of these vascular walls, give rise to rather acute pain which makes singing painful, specially when the throat is inordinately contracted.

I have known the case of a woman, whose pharynx offered granulations on the lateral walls of its lower part; under the influence of alcohol, an inflammation arose which had the immediate effect of rendering her aphonous. Her friends, who had remarked this singular irritability of her throat, used to amuse themselves and make her drink a glass of Chartreuse, which made her for half-an-hour absolutely unable to speak. This reflex process disappeared after the cauterization of these easily inflamed granulations.

Larynx. — As regards the larynx, a series of diseases can be observed which interfere very seriously with the vocal function. An artist, who overtires his organ, is subject to a passing hyperæmia of the mucous membrane which vanishes a few hours after practice, also to the congestion of the vocal cords and of the ventricular bands, and to the inflamed condition of the tissues which alter the purity and the flexibility of the tone.

Then, tumefaction and thickening of the mucous membrane take place; the cords lose their nacreous aspect and their polish; they are distorted, deformed, they bulge in the middle in such a way that, in the approximation of the cords, a triangular space occurs in front and in the back of the projection, and lets the sound go out in sheer

waste. On the cords appear reddish vessels which can engender at a certain time blood diffusions.

The voice is less flexible, less clear, less sonorous, the half-tints are impaired. The artist feels the necessity of heating his voice to obtain a clearer tone; but he only succeeds in getting a covered voice, in provoking hoarseness, huskiness, tremolo and in feeling the need of expectoration, in consequence of the fatigue due to the efforts which have to be made to produce the tone.

Singing on a cold or during the course of an acute laryngitis, determines frequently a condition of hoarseness which compells the artist to take a lengthy rest. It is however possible, thanks to a treatment which relieves the congestion, to stop this ailment and allow the singer to take his part. But if the disease is already a few days old, the loosening of the mucous membrane is to be feared; it appears under the shape of a slight swelling which floats on the edge of the cord. It is unnecessary to say that when this is the case, the artist must keep absolutely silent and submit himself to a regular treatment, if he does not want this hypertrophy to become keratodeitis, giving rise to a kind of nodule.

An excessive effort of the voice in the singers, hawkers, etc., can determine the production of a sub-mucous hemorrhagy which takes the form of an aneurismal dilatation of a vessel, but which spreads sometimes on quite a large portion of the cord, in a diffuse sheet.

Certain authors have denied the existence of the granular laryngitis, on the pretext that there are no glands on the border of the vocal cords; however others, like *Fränkel* and *Heymann*, have cited some such cases. Like the latter, I have had the opportunity of seeing, on the border of the cord, a kind of small tumour of the size of a grain of millet, reminding the sebaceous gland, the comedon. It takes the shape of an accuminated speck, whitish at the top. The matter which is therein contained makes a slight prominence, and comes out of its pouch only with difficulty. This tumour is generally covered over with a very adherent layer of mucus, of milky appearance, which gets loose by the efforts made in coughing, or by the means of a probe with cotton-wool, or else after alkaline pulverizations directed fully on this point. This disease, usually accompanied by hyperæmia of the cord, arises principally in artists suffering from naso-pharyngeal catarrh, and abusing a too stimulating diet.

For a long time, I did not believe in the existence of this sort of granular laryngitis, until the day I witnessed three such cases in the space of a few months; in the case of one artist several relapses occurred.

The *nodule*, ordinarly develops on the border of the cord, at the junction of its anterior third and its two posterior thirds. Following

a condition of irritation, of hyperæmia and of swelling of the mucous membrane, a small projection appears which is caused by an hypertrophy limited to the epithelium and the subjacent tissue. There is generally only one such prominence, but another can form itself on a corresponding point of the other cord.

Besides arising from the above-mentioned cause, the nodule can also be provoked by the abuse of the shock of the glottis. I have seen one occur in the case of an artist which I followed regularly. Having read *Faure*'s method, he wished to try this artist's way of producing the tone, and made the effort which was indicated; but the fatal nodule made its appearance!

I have observed a series of relapses in a tenor who delivered all his tones by means of the shock of the glottis, which his professor stedfastly insisted on making him use. After a first complete ablation the tumour reappeared the following year; a second ablation was made; again the tumour reformed itself, and so on three years consecutively. This artist, who had already a long career behind him, was singing at least three times a week very variegated Opera stock-plays. In the course of the two following years, the nodule did not form itself again; besides the singer got very few occasions of making himself heard during this period.

The spoken voice is veiled and betoned, the production of the high notes is impossible, the middle voice is bad, however some tones can still come out in *forte*. The « roulette » is one of the manifestations of the presence of the nodule.

The question of the treatment of this ailment is very disputed by certain practitioners who contend that the cure may last several years. If, in the beginning of the disease, recourse can be made successfully to medical treatment, the organ being made to rest, and the tumour receiving applications of appropriate medicaments, it is a different mater if the nodule is already formed since some time, or if it has already reached a certain development. It must then be taken away. This method is the one I have used in the case of the afore-mentioned barytone. I must add that, in reason of certain circumstances, he was compelled to sing five days later and to take part in the dress-rehearsal of the thousandth performance of a celebrated opera. He fulfilled his task with great success and without being inconvenienced; twenty years after this operation, he was still holding the leading parts in the same theatre.

The paresis of the vocal cords is far from being rare in pupils who singing at first without effort, find some difficulty in the course of their studies in delivering the passage notes, owing to the inordinate use of the chest register, or of the sombre timbre. Very soon the high notes can only come out if an effort is made, and the voice being strained needs a long rest. The vocal cords do not

come any longer close enough together in phonation and they stay apart, leaving the breath to come out without being able to produce the normal tone.

This malady results also from the emission on the breath, and from the abuse of straining, as well as from the exaggeration of the range of the tessiture which certain professors demand of their pupils.

Phonasteny-Mogiphony. — This is a functional disorder of the voice, characterized by the absence of gross mechanical lesions (*Flatau*).

More frequent in artists having already a long carrer behind them, during the course of which they have spent themselves in vocal efforts due to an incorrect emission, a defective breathing, a weak attack (on the breath), and specially to the use of the sombre voice, or of erroneous tessiture, it arrives also in beginners who miscalculate their strength and undertake a task exceeding their capacity, by recurring to all the wrong methods which have just been enumerated.

The lesions which are visible are very slightly marked at first; one can just observe a slight inflamation of the pharynx, along the posterior pillars; later, the mucous membrane tumefies, enlarges by spots in this place. The vocal cords offer also a slight congestion, often limited to certain parts, but generally to the free edge. Instead staying smooth and nacreous, they lose their polish and become rugose. The ventricular bands lend sometimes their compensating assistance to the movement of adduction of the glottis, movement which is no longer sufficient to contribute to the tone formation.

The sufferers show an increasing vocal fatigue which compels them to take a longer rest each time they have sung.

The phonation is painful, and the subject avoids speaking in a loud voice, because of the prickings and ticklings which oblige him to cough convulsively. The tone loses its justness and intensity; the shrill notes do not come out if one tries to sing them softly; the voice becomes weak and gets out of tune or is stopped abruptly; this phenomenon, commonly called « rupture of tone » or « thread in the voice » compels the sufferer to take a long rest.

Besides the dryness and the burning felt in the gullet, the subject experiences some fatigue in the muscles of lips and cheeks, and pain in the lower maxillar, the pharynx, the nape of the neck and even in the thorax; the latter facts are not astonishing if one remembers the participation of the muscles, of both neck and thorax, in the making of the effort which, finally, ends by a vocal disaster very difficult to overcome.

To these symptoms may be added anguish, heart palpitations, pallidness with formation of drops of perspiration on face, brow and temples. When one has been once spectator of such a painful scene one cannot easily forget it. There is really something poignant in the sight of the unhappy artist, fighting vainly to surmount his sufferings, and finally breaking down on the stage, no wind left, streaming with cold sweat, exhausted by the effort made to try and utter a tone which remains in the throat, and with a gesture of despair, showing that he has no longer any power of control over his vocal organ! I remember a tenor who, at a time had a well deserved reputation, and who finished his carcer in that manner.

When the malady is not too far developed, it is possible to cure it by means of rest, change of method and use of electricity, massage, strychnine, etc.

Tremolo. — Tremolo is a kind of bleating which causes the tone to vary in pitch with each jerk. It is occasioned either by the fatigue of the thoracic muscles, the laryngeal muscles or the organs of articulation, either by the abuse of sombre voice, by a defective emission, an inordinate effort of the midriff, the straining which is a consequence of abrupt attack, or else by a nervous disorder, like stage fright, for instance.

The following example of tremolo, caused by the midriff, has been given by a soprano. By examining the respiratory graph taken by means of the pneumographie apparatus, one can ascertain that the line of the abdominal breathing, instead of being regular like those of the clavicular and sternal breathings, offers a series of undulations, which indicate the lack of harmony in the respiratory

Figure 159.
Graph of the respiration in a case of diaphragmatic tremolo.
C Clavicular breathing — *S* lower costal breathing
A diaphragmatic breathing.

function, between the thoracic muscles and the diaphragm, a condition which I have been able to confirm by the radiographic examination of the thorax : the midriff, instead of rising regularly, worked by jerks which lowered it at times.

The upper line represents the outline of the clavicular respiration; the middle one, the outline taken on the level of the lower ribs; the lower line, the outline of the abdominal breathing.

The following figure (Fig. 160) is the reproduction of the phonographic registration of the voice of a pupil, in the case of whom the tremolo arose from the convulsive movements of the jaw. The examination of the graph shows the differences in the intensity of tone and the changes in pitch, so as the imperfection in timbre.

Roulette. — Roulette is a passing vocal trouble, characterized by a kind of rolling noise which, in general, is heard on the same note, and is due to the grazing of the vocal cords mucous membrane during phonation. It is caused by a small nodule, or by a mucosity adhering to the border of the cord.

« **Couac** ». — The couac puts in mind the cackling of the ducks, hence its name. This accident arises out of the involuntary passage from thick to thin register, with sudden return to the original register. It is habitually provoked by a mucosity which gets loose from the border of the cord, and generally is only produced in the upper notes of the deep emission.

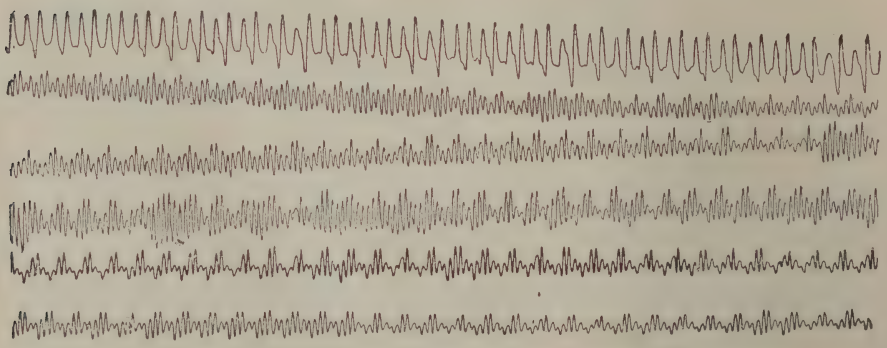

Figure 160.
A, I, A, sung on La^3.
The tremolo is seen to accompany the graph frequently.

Phlegm or « **Chats** ». — Phlegms are produced by the presence on the cord's borders of mucosities which alter momentarily the production of tone. It is when they suddenly get loose that the « couac » occurs.

Phlegm is specially prevalent in artists who, for the purpose of making a thinning cure, avoid so carefully drinking that they hardly take a glass of liquid daily. This symptom can also be the consequence of trachitis or of nasal catarrh.

Stage fright. — This nervousness is caused by the tremor which seizes the artist when going on the stage.

Stage-fright — or trac — afflicts seldom beginners, but often competent artists who are anxious to fill their part conscientiously. They could often hold their part, and non-informed spectators would never notice a slight lapse which would pass unobserved. It is necessary to have followed such artists closely, to realize the suffering they endure.

In writing these words, I am thinking of one of our greatest artists, preyed upon by a tremendous « trac » at the moment when, having hardly recovered from an indisposition, she was called to create an important part. Will the extent of this nervousness be grasped if I add that one day, to render a service to management, encouraged by the doctor who was treating her, she accepted to sing, in spite of the vocal difficulty she was feeling, one of the leading parts of a Wagner opera, but she could not continue till the end of the performance and was obliged to leave the stage before the fall of the curtain. Also the day when she was going to sing the part of *Marguerite* of *Berlioz*, she was so overcome with nervousness, though I told her I was feeling absolutely confident everything would go on normally, that she went on the stage like an automaton, and played without realizing that she was singing just as usual, though if she had known that this was the case, she would certainly have recovered some confidence. It is only when the performance came to an end, that she felt herself again, having been told from all sides that she had been equal to herself.

Some artists who have a silent form of « trac » guard themselves from speaking; their countenance only, or their way of breathing reveals their uneasiness and the anguish, which seizes them at the thought of not playing up to the mark of their customary talent, specially when they take up a part previously held by a colleague of great renown.

In nervous people, stage-fright gives rise to scenes equally painful for the artist and the practitioner.

One of our great women-singers who is very difficult with herself when her art is in stake, and always refuses to sing at the slightest painful feeling in her throat, out of fear principally of coughing on the stage (though this has not once occurred to her), begins to be nervous several days beforehand at the idea that she could lapse, ever so slightly, during the course of the representation.

The day of the performance and the day before, she is seized by anguish, tightening of throat and chest, palpitations, looseness, and, above all, by a feeling of dryness which the condition of the mucous membranes does not justify. Her organ is in good shape, but she is so much afraid of not being all she ought to be, that she worries the doctor to know if in the remotest parts of her throat, there is not some kind of inflammation or granulation, and instead of being quieted by the assurance she receives that every thing is all right, she passes a dreadful day which she tries to shorten by going very early to the theatre, with the hope that the « trac » will disappear sooner. She paces backwards and forwards in her dressing-room, avoids talkers, rushes in the wings, all the time trying to control her nerves. The curtain rises; she declares that she will certainly be obliged to stop, and that at the smallest hitch she will let every thing go, performance and theatre. The tone comes out; she is not yet secure, she feels that her organs are not placed in the position required for the production of tone, she frets; but if she manages to take a deep inspiration, mouth shut, all is right at last; she has now the feeling that her throat being relaxed, she can easily go up her larynx; having once more the control of her organ, she can without effort deliver the deep and the shrill notes, and the doctor is at least as relieved as herself, when he notices that her voice is no longer tight, that she holds her tones, succeeds in making half-tints and that, in one word, she plays with her breath.

It is in such cases that the benefits of a good respiration are made evident.

Though the « trac » shows on the mucous membranes of the throat no perceptible trace of any lesion whatever, I have however, in several instances, brought by the tightening of the organ, witnessed the development of hyperæmia, principally localized to the lower and lateral walls of the pharynx, and of a swelling of certain points of the lingual tonsil which got inflamed by the friction of the lid. Therefore one must not be surprised if the « trac », or rather the contraction of the pharynx, be an element with which one must reckon in cases of congestion of the vocal organ.

CHAPTER XX.

ON THE TASK OF THE LARYNGOLOGIST IN THE MATTER OF SONG.

At the same time as I wish to draw the attention of the laryngologist upon his duties towards the voice-users, I have also the desire of answering certain criticisms directed against the specialists who have made a special study of speech and song, and of the treatment of their ailments.

If some learned artists know and understand the working of their vocal apparatus, and use it without impairing it, it is not less certain that many teachers, lacking the necessary instruction or experience, abuse the organ of their pupils to such an extent, that they make them lose their voice.

For this reason, I am far from agreeing with the opinion of certain practitioners who do not admit that the specialist can pass a judgment upon the voice, the emission and the classing, and leave to the singing-master alone the care of finding out the condition of the pupil's larynx, forgetting that it is often the fault of the master when the disciple is unable to sing any more. However they are willing to concede to the laryngologist the concern of letting the artist know that his vocal cords are spoiled, that he is on the right way of losing his voice, that he needs rest, and that later on he may take up his studies again, if he has recourse to proper technics which wo 'nt tire him. I do not believe that our duty consists only in saying to the bearer of a worn out larynx : « Look out, stop! I do not know what you are doing, but certainly your way of working is wrong. Your larynx is in a bad condition, ill-used, tired and cries for mercy ».

Besides I do not think that any competent laryngologist would care to understand his task in that manner, especially if he finds himself in presence of an organ impaired by a professor who has been unable to train the voice of his pupil properly. The client will

not be satisfied simply by the advice, that he ought to change of professor, or adopt another method; he will want to know why his voice has gone wrong, and will inquire about the cause of the evil. Will the practitioner who is aware of the necessity for the singing-master of knowing the working of the vocal apparatus, science which is not taught in the schools, will he himself be compelled to confess that he ignores the means of producing and delivering the tone, and of disposing the organs of articulation? Will he be obliged to admit his incompetency to give the sufferer satisfaction, regarding the point which is of chief interest to him, and to tell him the reason of the disorders of which he complains?

The practitioner, who has made a special study of the vocal organ, is at least as qualified to pronounce a judgment upon the voice as a journalist or a critic, even if he is a composer, this fact being insufficient to justify a claim to the knowledge of the voices' tessiture. On the contrary, he has the right of thinking that he is more able to appreciate the quality of the voice than a man who, having left the stage to take up professorship, has never succeeded in forming one single artist capable of making a decent theatrical career; and I doubt that he would submit to his judgment, and agree with him that « laryngologic science will never teach how to place the tip of the tongue and the soft palate, in vocal production, no more than it will make clear what is the right place of the tone on the breath ». In spite of the saying of this singing-master, I am convinced that the laryngologist is as well placed as he — if not better! — to know the right way of breathing, of attacking and delivering the tone, so as the manner of disposing the organs to obtain the desired result, and will not be content to use simply vague and meaningless expressions, such as : « to place the tone on the breath » for he, the laryngologist, knows that it is the breath which produces the tone in passing through the larynx, and that articulation and emission depend on the place occupied by the organs, and on the shape they take inside the upper-laryngeal cavities.

A doctor can be compared to an architect; both can be called to repair the organ or the building which has been ruined, and of intrusting the care of the reparation to the competent people; but the result can only be satisfactory, if the one and the other realize in what way to proceed to attain this aim, by means of appropriate technics. The laryngologist cannot possibly tell a singer to use the right technics, if he does not know exactly in what it consists; he must therefore have sufficient notions so as to distinguish a good theacher from a bad one.

Unfortunately bad professors are not rare. The primordial cause of the defective tuition of song comes, as I have clearly stated, from the lack of schools given to the preparation of teachers. The

State has left until now entire latitude of teaching the art of singing to the first comer who choses to call himself singing-master, a privilege which has never been granted to any one destined to ordinary professorship. A diploma is required from the schoolmasters and gives its owner the right of teaching, but no certificate of aptitude has ever been asked on the part of anybody desirous of opening a singing institution. It is therefore not surprising if so many teachers ignore the way of breathing, of delivering the tone and of pronouncing. This is the reason why the laryngologist has often the occasion of verifying the disastrous results of such a tuition.

In the beginning of the studies, the specialist ought to be consulted, so that it may be known if the aerial tube of the future singer is in good condition, for it is necessary to clear the cavities of the nose and the pharynx from every impediment which would be liable to bring disturbance in the production of tone. Unhappily the sufferer, who comes to consult us, does not always take heed of our advice, especially so as he is influenced by certain professors who are against all treatment. The latter forget that they themselves would have been able to continue a career prematurely broken, on account of lesions which would have disappeared if they had shown more confidence in the doctor, instead of recurring to smearings of the throat, or to oil instillations which they ask somebody, quite incapable of appreciating the state of their organs, but who is handy to practise on them.

One must know that the singers pay more attention to their vocal cords than to the perviousness of their nose. However the artist who does not breathe freely will never be able to introduce a sufficient amount of air into his lungs; he will find great difficulty in controlling his breath and, consequently, in delivering the tone under favourable conditions : one day or another he will end by *straining*, according to the usual expression, and straining leads to congestion; straining means that the note will soon be taken underneath the tone; straining, lastly, hastens the formation of granulations, principally upon the lateral walls of the pharynx, granulations which will impede the normal play of the organs.

How often have I warned artists who persisted in keeping the obstacle situated in the nasal cavities or in the pharynx, that a day would come when they would find themselves compelled to abandon their career, or, at least, that sooner or later they would find some difficulty in delivering the tones! One is rather inclined to laugh at the foretellers of evil; but, in this case, they have their revenge, when a few years later those who had believed themselves thoroughly competent in the matter, come to find them again and confess their mistake; but often nothing can be done, the voice is lost and it is too late to save it!

A fact which ought to force the attention, and which can be daily ascertained in our theatres, is the length of the career made by an artist who knows how to breathe. I myself have had the occasion of rendering pervious the nose and the pharynx of actors who, having got rid of the obstacle which impeded them, have been able to preserve their voice for more than thirty years after the operation.

Besides these cases are others of artists who have held leading parts, but who have disappeared from the stage, cutting short a brilliant career because they have lacked confidence in the counsels of their doctor. Actually, we can observe around us certain theatrical stars who, for the same reason, are already declining and will only have been shooting stars. But, as it always happens in this case, they lure themselves with the thought that they have never been in better vocal shape. Have they not the facility of repeating every morning twenty times, that their voice is excellent, to be deluded and to have the conviction their organ will be cured by means of this suggestion?

As aforesaid, the singer, and even the practitioner, believe that the disorders of the voice arise most of the time out of the condition of the vocal cords. « There is nothing the matter with your cords », such is the decisive phrase with which the artist is assured that his voice must be excellent, phrase, unhappily too frequently repeated by inexperienced doctors. However some cautious singers insist, in spite of the condition of their cords, and remark that, deprived of their customary means, they feel a great difficulty in doing their work, and hardly dare even to sing, fearing not to be able to go to the end of the performance.

What responsibility incurs the doctor, when, in similar cases, he induces the artist to sing, by giving him the assurance that he will find no difficulty in going to the end of his part, as his vocal cords are perfectly healthy. And what a disaster when the artist, exhausted by his efforts, is obliged to leave the stage without being even able to finish the piece he is singing! It is not necessary to insist upon the ruin which would befall the reputation of the laryngologist to whom such a happening would occur.

Though I do not give the vocal cords all the importance which has been, until now, credited to them, it must be recognized that, as they are charged with the distribution of the air into the vocal organ, any impediment, which would fetter their play, is liable to give rise to trouble in the production of tone.

It has been previously explained how the tone was formed in the *ventricles of Morgagni*, the working of which must not be made defective, either by an obstacle preventing the increase or decrease of their capacity, either by an untimely contraction of the extra-

laryngeal muscles. One must not forget that the inflammation of the laryngeal mucous membrane spreads easily to the mucous membrane of the ventricular cavity, thus provoking a notable impedement to the formation of tone.

It must be borne in mind, that the integrity of the pharynx is necessary to the good emission of tone, and that the play of tongue, soft palate and lid must be free, so that the articulation should not be altered. Therefore the laryngologist must give the utmost attention to the examination of these parts.

For a long time no heed was taken as regards the condition of the singer's nose and pharynx. I can remember a time, going back to the first days of the Society of Otology which had just been founded on my initiative, where having had the occasion of mentioning the posterior rhinoscopic examination, two of my colleagues, very well known in the oto-laryngologist world, expressed a doubt as to the possibility of exploring the nasal pharynx; one of them had reinvented a certain prism made to show, badly rather than well, the image of these parts. The intervention of a foreign practitioner was necessary, to make the refractory members admit that the posterior rhinoscopy was not to be looked upon as a matter of extraordinary curiosity, but could be used currently by all those who had the patience of practising it. This method is now utilized daily, when it is necessary to get an indication regarding the condition of the back part of the nasal cavities, and of the roof of the pharynx, and reveals the obstacles which hinder the production of song.

The play of the lid can also be impeded by the presence of the same hypertrophied follicles of the lingual tonsil; the lid catches itself in these prominences, hence arises an obstacle to the emission of pure tone. Furthermore, during vocal practice, this reiterated friction can provoke a congestion of the tonsil, determining fits of coughing.

Is the lingual tonsil strongly hypertrophied? If so, one can observe how can be altered, in consequence of this fact, the configuration of the cavity constituted by the base of the tongue in front, and the posterior wall of the pharynx in the back, cavity which is of great importance with regards to the production of tone and the formation of certain vowels, as previously indicated.

Likewise when a granulation develops in the dihedron, formed by the base of the tongue and the lateral wall of the pharynx, the singer finds difficulty in producing the voice; he can also feel a prickling, the cause of which is discovered if one takes the pains of stretching these parts aside; thus one finds the origin of the evil hidden in the folds of the mucous membrane, and one has the explanation of the impediment felt in the emission of the clear voice, the high notes and the vowels *i* and specially *é*, for the produc-

tion of all of which the close approximation of the larynx with the back part of the pharynx is required. On account of the diminution of the antero-posterior axle of the lower part of the pharynx, the granulation is compressed against the walls; it gets irritated, inflames, provokes coughing, and produces the phenomenon known by singers under the name of *thread in the voice.* One can judge of the passing aphony which can be caused by this small tumour by touching it with a stylet. I have indicated previously that a liquid strong in alcohol, in passing over this inflamed granulation, determined a complete aphonoy of several hours.

Likewise the presence of granulations behind the posterior pillars, on the level of the soft palate, causes a trouble of the voice, during the passage of tone.

I have witnessed many such instances in the course of my career. I will only cite the case of a near relative of one of my colleagues, a renowned laryngologist. In despair at seeing that she was losing her voice, in spite of all the treatments employed, she came to consult me. I discovered the presence of granulations on the lateral walls of the pharynx. Their destruction, by means of the galvanocautery, restored the voice of the artist, who was then able to take up her career again. I found confirmation of the fact in a communication made, some time afterwards, by this colleague to a medical Society, concerning the efficacity of this treatment in singers, treatment to which he himself had not had recourse for his relative, but of which he had been able to judge the benefits, as after each application of galvanocautery by me, this lady used to call on him.

The laryngologist must also remember that the singer is inclined to follow blindly the advice of his colleagues, and therefore will try in turn all sorts of remedies as homeopathic granules, aconite, crysimum...; one day he will favour subcutaneous injections; another time his preferences will go to intra-laryngeal oil instillations.

These medicinal oil injections were used at first to fight tuberculosis; their elimination is effected by the lungs. I do not see the advantage of recurring to such a process which is not always without inconvenience, when one can dispose of easier and more effectual means for introducing the medicaments in the wind-pipe.

Tracheal injections are known since a very long time : they have been the matter of hot controverses in the United States and in France, about the year 1855. I have frequently applied them, in the beginning of my studies, in *Störck*'s clinical hospital at Vienna, where they were used for the cure of tracheal affections. At that time, water alone was used as carrier of the medicaments, as oil was still unknown. It is after studies of *Rosenberg*, of Berlin, who employed, dissolved in alcohol or ether, menthol (of which the analgesic propriety had been discovered many years previously by a

French doctor: Dr *Delioux de Savignac*), that I have, the first, replaced alcohol and ether by vaseline oil. The result of my researches have been published in the *Progrès medical*, dated 5th september 1885.

If one can have recourse without danger to these injections in the treatment of pulmonary tuberculosis, it is a different matter when one has to consider the case of an aphonous artist who asks to be able to sing the same evening. The introduction in the wind-pipe of oily mixture, which is not immediately absorbed but mixes itself to the existing secretions, can provoke a disorder in the emission of the voice, by giving rise to phlegm and even hoarseness.

Other processes, like pulverization or medicinal nebulization, are less noxious and more effective. Pulverization, with appropriate instruments gives a fine spray, and nebulization produces a cloud, the temperature of which can be carried to the desired degree. These processes have given me far better results than the application of oily instillations in the wind-pipe and, until now, I have never met with any inconvenience in using them.

For a long time, many singers showed the greater reluctance in having any kind of instrument introduced in their throat. They can be excused to a certain extent in presence of the fact that, even actually, some of our colleagues declare that they are opposed to these forms of treatment, and prefer internal medication or rest!

However certain cases are not rare, where success has been achieved in enabling a singer, suffering from laryngitis, to sing in the course of the same day, by resorting to local treatment. Likewise certain processes must not be forsaken, under the pretext that « a light application of chloride of zinc or of gomenol oil (which is so much in use since it has changed name [1]), has never succeeded in curing an alteration of the voice brought by an erroneous classing, or by the abuse of chest voice ». For instance, in such cases as of disorders caused by vocal fatigue, in conjunction with the rest of the organ, use ought to be made of strychnine, massage and electricity.

If some laryngologists are afraid to practise some operations on the throat of singers, under the pretext that the artist can accuse the practitioner of having definitively spoiled his voice; if others even reprove all endolaryngeal treatment, one can counter them by pointing out that several lesions, determined by the ill-use of the voice, can retire great benefit out of cauterizations by means of the galvanocautery, and even out of the use of certain instruments.

How can one indeed get rid of granulations which are developed in the lateral walls of the pharynx and resist every medication, either general or local, if recourse is not made to the galvanocautery? I leave aside the possibility of their ablation by means of the scissors,

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1 Niaouli, very common in the region of Gomen (New Caledonia).

a process which I do not advise in this occurrence. If the cautery is handled prudently, care being taken to avoid attacking the submucous tissues — as has wrongly been done by some daring practitioners who have thus caused adhering scars — excellent results are obtained. The untoward use of the thermocautery has, for a long time frightened, not without reason, the artists who feared their grievous consequences. I cannot sufficiently recommend making use of any kind of instrument, only with very light hand.

This way of proceeding has enabled me to give a certain number of artists, who had left the stage, or had the intention of doing so, the means of taking up again, or of pursuing their career. Amongst some such cases, I will cite the instance of a barytone who had given up singing since ten years and who, after a treatment of a few months, entered the theatre and stayed there for more than ten years, until he became the manager of one of our principal French lyric stages. I will cite also the case of another artist who, for this same reason, viz. : ill-use of the organ, had such pains in delivering the tone, that he had lost entire confidence in himself, fearing he might have to stop in the middle of the song. This unhappy artist suffered from such acute nervousness, that he had decided to abandon his career which had been a very brilliant one. I have been able to restore to him all the vocal means he possessed at his « débuts », and he occupies actually a leading place in one of our lyric theatres.

But if I approve of the use of galvanocautery, I am absolutely against employing the scoop in the larynx, as it is difficult to limit its use, and therefore a loss of the vocal cord substance can result, an accident of which I have observed, in the space of less than a month, three cases in artists operated by the same colleague; it is useless to say that these three unlucky singers were compelled to abandon their career.

Amongst the instruments, with which nodes or polypus of the border of the vocal cord are extracted, I give the preference to the forceps which *Ozanam* had made by *Mathieu*, in 1875, and which are now known under the name of Dr *Dundas Grant*'s forceps. Many are the practitioners who show some reluctance, in having recourse to sharp instruments, when they find themselves in presence of similar cases; they prefer waiting for months, and even years, and leave the voice to rest. As for myself, I may say that I have never found any sufferer who seemed willing to make such a trial. I remember that in the first years of my practice an artist, who had already quite a big reputation, came to consult me. He was bearer of a nodule on the border of one of his vocal cords. I will not insist on the apprehensions I felt in the presence of this singer. I even went so far as to tell him that if the operation did not succeed, his voice could be so altered as to oblige him to leave the stage

« If this operation is not successful, its result will not change me as an artist, as I am now incapable of singing, therefore you can operate on me », such was his answer, and I was obliged to comply to his wish, as I had no longer any reason to draw back. The result of the operation was excellent, and the patient was able to pursue his career until quite lately, giving numerous and brilliant representations in France and in foreign countries, where he has left the reputation of being one of the greatest artists of our days.

Concluding, I go so far as to say, that the task of a laryngologist is of a very great importance in the matter of singing. He must not content himself with ascertaining the vocal fatigue or the ill-use of the organ, but he must endeavour to discover the causes thereof, and indicate them to the artist by all means which are at his disposal, to make them disappear; he must not keep his arms folded, apprehending the use of an instrument which can restore the integrity of the voice, in such cases as those to which I have referred above.

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